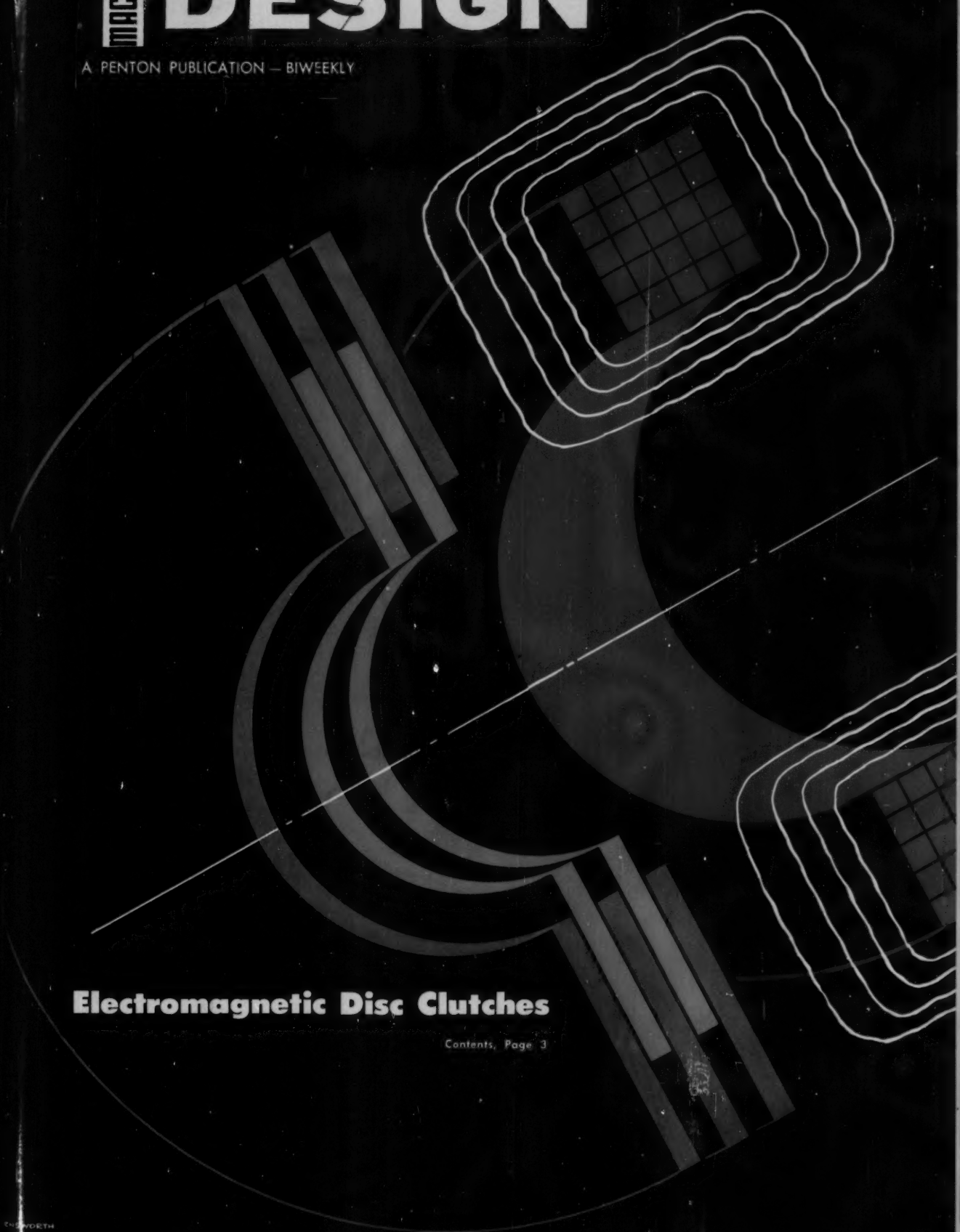
AUGUST 4, 1960

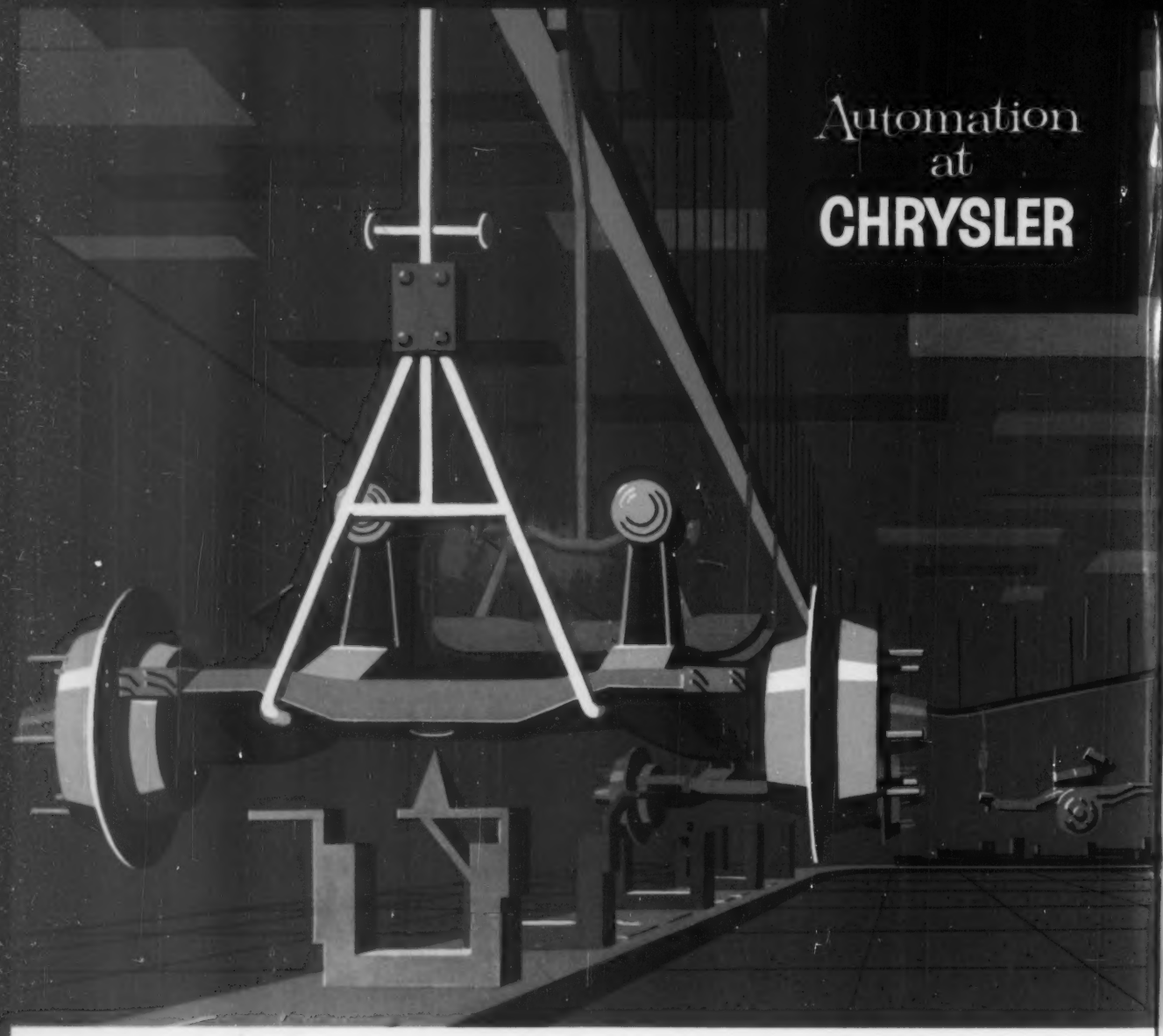
MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Electromagnetic Disc Clutches

Contents, Page 3



VARIDYNE a/c drive system synchronizes assembly conveyors

Problem: Chrysler Corp., Dodge Division, new unitized body assembly lines required linkage of three *variable-speed, continuous motion* conveyors—stub frame overhead, main assembly pedestal and final assembly flattop. At transfer point, shown above, pin in conveyor must match hole in frame with no cumulative error.

Solution: U. S. VARIDYNE a/c Drive System with *LinkSync* control. Chrysler engineers working with U. S. Motors field engineers chose VARIDYNE over a d.c. system because: initial start-up is simplified; instantly synchronous without warm-up; needs no synchronizing readjustments; there is no cumulative error; and maximum reliability is assured by use of *standard a.c. motors.* VARIDYNE varies the frequency of a.c. current to these motors, converting them to adjustable speeds. *Write today for* VARIDYNE *Brochure F-1963.*

U.S. ELECTRICAL MOTORS INC.

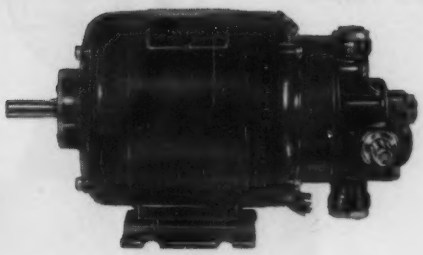
P. O. Box 2058, Los Angeles, California or Milford, Connecticut

Circle 401 on Page 19

MOTOR USER'S CASE HISTORY

"Bodine Motors are DEPENDABLE"

Massa, A division of
Cohu Electronics, Inc.

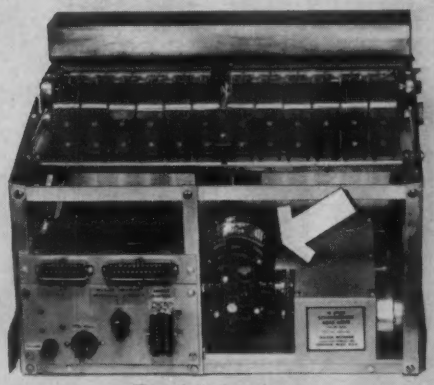


"We tested several makes of fractional horsepower motors to power our 12-channel rectilinear recorder and selected Bodine Motors for these reasons . . . dependability . . . quietness of operation . . . superior design . . . quick delivery . . . better packaging . . . company reputation. Also we wanted a motor that had a high starting torque. This torque is necessary to attain the instantaneous chart speeds required of our recorders. We found Bodine Motors to have excellent starting torque."

. . . Ernest A. Massa, vice president
Massa, A division of
Cohu Electronics

Here's the Massa 12-Channel Recorder . . . powered by a Bodine Fractional Horsepower Motor

This direct writing oscillographic recorder can record 12 signals simultaneously! Its chart driving mechanism is powered by a Bodine, synchronous, split phase, reducer motor (see arrow). A clutch arrangement makes it possible to obtain 18 different synchronous chart speeds.



Rear interior view

3500 standard built-to-order BODINE MOTORS!
300 stock BODINE MOTORS!

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More than 50 pictures, drawings and tables give detailed information on the Bodine line of worm gear speed reducer motors. A special section discusses, "factors in the application of speed reducer motors." Also included is a "characteristic chart" on various motor types. Ask for Bulletin 10228, Bodine Electric Company, 2508 West Bradley Place, Chicago 18, Illinois.

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Circle 404 on Page 19

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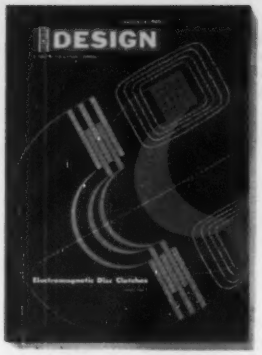
Circle 405 on Page 19



Front Cover: Friction discs and electric coil are the key elements in artist George Farnsworth's image of electromagnetic friction clutches. Factors in electromagnetic-clutch selection and application are discussed by Bob Kotnik in his article beginning on Page 113.

August 4, 1960

Power Behind the Karts 24

News Report—Spurred on by go-kart enthusiasts, manufacturers of small gasoline powerplants have come up with some amazing engine-design innovations.

Preparing a Design Handbook 104

R. W. BECKIM—A step-by-step guide for producing a handbook that meets the needs of a growing engineering group for efficiently distributed design information.

Electromagnetic Disc Clutches 113

ROBERT L. KOTNIK—How factors of load, torque, heating, cycling, and controllability affect selection of electrically operated and controlled friction clutches.

Vibration Isolation Design 123

DENNIS P. HANLEY—A new method for dynamic analysis of displacement-excited motions where loads carried by a spring and damper must be determined.

Thermal Stresses in Design 129

S. S. MANSON—*Part 21: Effect of Mean Stress and Strain on Cyclic Life*—How to estimate cyclic life of parts which have been subjected to tensile prestrain.

Slider-Crank Whip 144

GEORGE W. MIDDLETON—A method for isolating a connecting rod from its adjoining links so that the amplifying effects of inertia forces can be predicted by calculation.

Designing with Vinyls 147

C. W. BULKLEY—*Part 2: Vinyl Properties*—Engineering data on rigid and nonrigid compounds; effects of environmental conditions on design considerations.

Acceleration • Velocity • Distance • Time 151

V. F. DeVOST—*Data Sheet*—A chart for rapidly estimating velocity, displacement, and time at constant acceleration of powered vehicles or free-falling bodies.

Modular Design for Mechanized Assembly 153

A. ARNOLD LAWSON—*Design Abstracts*—Basic design concepts for automatically produced modular components and principles of mechanized assembly for modules.

CONTINUED NEXT PAGE

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

August 4, 1960
Volume 32 — No. 16

Job Recipes 103
ROBERT L. STEDFELD—*Editorial*

Engineering News 6

All-weather helicopter 6
New corrosion theory 6
MIND: Ceramic neuron 8
Small-engine carburetor 10
Gas-turbine landing craft ... 10
Materials research center .. 12
Digital data by phone 14
Re-entry trainer 14
Stainless welding data 27
RUM: Undersea explorer 28
Vapor-growth semiconductors 30
Boeing "Hotshot" 32
Fresh air for spacemen ... 32
Thermionic generator 34
Metals Matters 36
Radiation-damage lab 39

Trends 22
Meetings and Shows 40
Short Courses and Symposia 43

Scanning the Field for Ideas 109

Split-field comparator permits precise centering of light—"dithered" contacts produce stepless output from transducer—liquid contacting probe adjusts pump diaphragm stroke—servoed silver plate adjusts its own temperature—rerouted flux permits spring to open a safety switch.

Design in Action 136

Packaged-component design simplifies radio servicing—caliper motion clamps brake discs in new crawler—indexing turret turns control shaft to select program—"bucket" design reduces cavitation in wobble pump for cryogenic fluids—limit switches count gear teeth for digital readout.

Tips and Techniques

Selecting drive components 122
Thermal expansion 128
Circle formulas 135

Design Abstracts 153

New Parts and Materials 172

Engineering Department Equipment 194

The Engineer's Library 196

Noteworthy Patents 198

Backtalk 212

Helpful Literature 164

Subject Index 17
Reader Service Cards 19
Advertising Index 211
Business Staff 211

IN THE NEXT ISSUE: Variable-stability aircraft . . . planning the engineering office . . . critical speeds simplified . . . controlling hydraulic pressure . . . thermal fatigue damage . . . vinyl forms and applications . . . predicting reliability . . . cold heading.

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First Vertical Blind Flyer

Instrument-flight-rule certification has been issued by FAA for Cessna Aircraft's CH-1C four-place helicopter. The first 'copter approved for marginal weather, CH-1C is equipped with a special control system which does not rely on electronic devices to maintain flight stability (many whirlybirds are naturally unstable). Certification permits the craft to be operated in weather minimums equivalent to those encountered by fixed-wing aircraft of similar capacity. Meeting FAA all-weather specifications required a two-year test program.

Performance, Clear or Cloudy

Gross weight, max (lb)	3100
Useful load (lb)	1035
Hovering ceiling, at gr. wt. (ft)	9600
Engine (bhp)	270 @ 3000
Speed, max. (mph)	122

New Theory of Rust: Protons Are To Blame

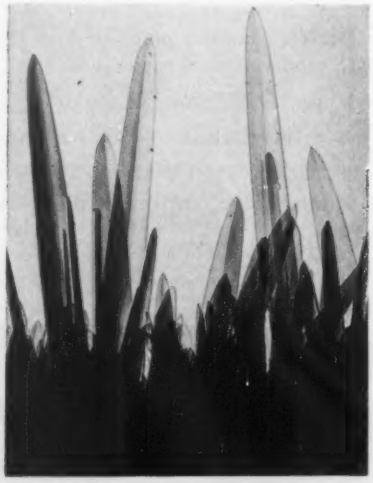
Tests Show Older Viewpoint Doesn't Fit All the Facts

PITTSBURGH—New experiments on corrosion suggest that the true culprits are hydrogen ions (protons), not electrolysis. According to a theory advanced by Dr. Earl A. Gulbransen and T. P. Copan, scientists at Westinghouse Electric Corp., these basic building blocks of matter penetrate iron and enlarge the sites at which oxygen normally combines with the metal.

The hydrogen ions, of course, come from water vapor. Because they pave the way for oxygen to attack the metal, they spread the reaction throughout the surface of the iron, causing it to rust.

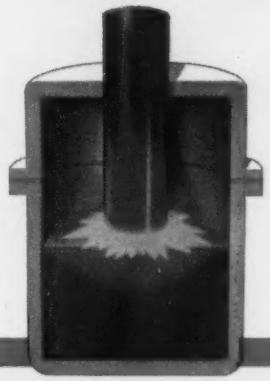
In their experiments, the researchers eliminated the conditions required for electrochemical reactions and reduced the complex rusting of iron to its simplest atomic processes. Pure-iron wires, about as thick as a fine sewing thread, were reacted at 835 F, first with oxygen, then with water vapor. Results were studied under an electron microscope capable of magnifying objects

Electron-microscope photographs taken at identical magnification, show effect of water vapor on the rusting of iron. In a dry-oxygen atmosphere (below) an iron-oxide coating forms to protect the surface. In a water-vapor atmosphere (right) the surface erupts into thin, blade-shaped oxide crystals.



WHEN MAXIMUM RELIABILITY AND MINIMUM REJECTS ARE REQUIRED

SPECIFY MIDVAC STEELS

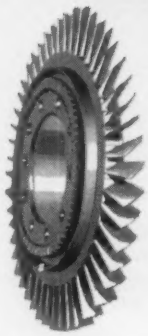


Simplified illustration of Midvac Process of consumable electrode vacuum melting.

Fine electric furnace steel electrodes are melted in water cooled copper ingot mold under vacuum of 5 to 50 microns

• Midvac Steels Are Produced By The Midvac Process Of Vacuum Consumable Electrode Melting

• Midvac super alloy and high strength steels are being used for highly critical parts in jet engines, missiles, bearings, reciprocating engines and places where high reliability is a "must". The Midvac Process of consumable electrode melting eliminates atmospheric contamination, ingot soundness is improved, segregation is reduced, workability is increased and rejects are held to an absolute minimum. M-H metallurgists are ready to help you select the right alloy to meet the specifications of your product. Write to **Midvale-Heppenstall Company**, Nicetown, Philadelphia, Pa. Subsidiary of Heppenstall Co., Pittsburgh, Pa.



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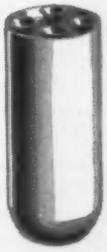


- Maximum Cleanliness
- Higher Ductility
- Improved Shear Forming

New technical data book on Midvac Process and properties of super alloy steels, melted by consumable electrode vacuum melting, now available upon request.

MH *Midvac Steels*

Circle 407 on Page 19

up to 300,000 times.

The scientists report that in dry oxygen the iron formed a protective oxide coating. Out of this grew billions of tiny round oxide whiskers. Each, less than one millionth of an inch in diameter and 30 millionths high, sprouted from a separate site on the wire's surface.

When the wires were reacted in the water-vapor atmosphere, the moisture produced a startling change in the oxide surface. From the growth sites, thin, pointed, blade-shaped platelets of iron oxide erupted and spread across the metal surface. Shaped somewhat like blades of grass, the needles were about one millionth inch thick by 30 millionths wide by 300 millionths high. As they grew, they spread over an area more than 50 times larger than the sites observed with dry oxygen alone. The amount of iron rust they represented is 250 times that which forms when water vapor (and the hydrogen ions it releases) is absent from the reaction.

The experiments show that less than one part water vapor per 200 parts dry oxygen will cause the blade-shaped crystals to form. At room temperature this would correspond to a relative humidity of about 3 per cent.

"We conclude that the hydrogen ions in the water vapor enlarge the areas of chemical reaction between the oxygen and iron and bring about the metal's greatly increased corrosion," Dr. Gulbransen declared. "At the lower temperatures at which iron usually rusts, this basic reaction is masked. Complex corrosion products are formed and are not stable; the corroding metal is often removed from the reaction site."

The new theory suggests that rust can be completely controlled only if hydrogen is prevented from entering the metal. Growth of localized reaction sites must be inhibited by suitable alloying elements.

Ceramic Toroid Mimics Neuron

NEWPORT BEACH, CALIF. — Self-organizing machines (they're capable of "learning") are being developed by Aeronutronic Div., Ford Motor Co. They're based on a nerve-like cell called MIND that can duplicate some of the functions of a human brain cell.

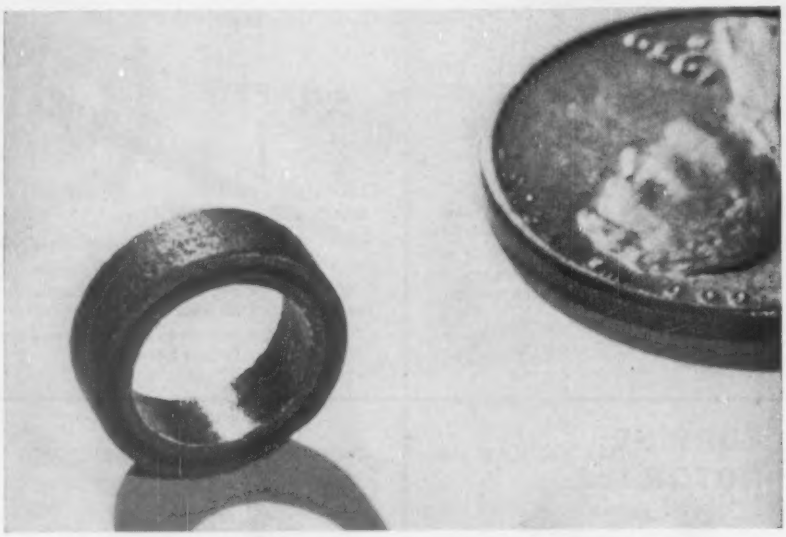
MIND—short for Magnetic Integrator Neuron Duplicator—was developed as part of research project perceptron (MD, July 7, 1960, p. 10). The device is modeled after synaptic junctions found in animal nervous tissue.

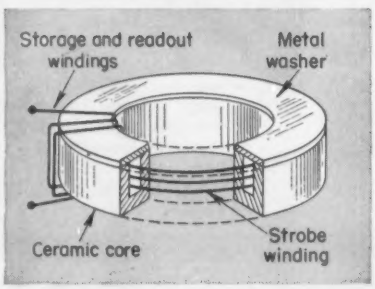
A MIND cell stores past events by increasing or decreasing magnetic flux retained in its circuit. Readout of flux is equivalent to "remembering" the electrical pulse that caused it. Readout is accomplished by applying a magnetic field that generates an output voltage similar to the input voltage which caused the flux residue in the first place.

A large number of MINDs, wired to form a nerve network, can be used to learn characteristic inputs and respond in a particular manner to each.

Low cost and high-speed response of MIND may allow much larger nerve-nets than ever before. "But we are still a long way from approaching the complexity of the human mind with its 10 billion neurons," says Ford. That many MINDs would stack up 80,000 miles.

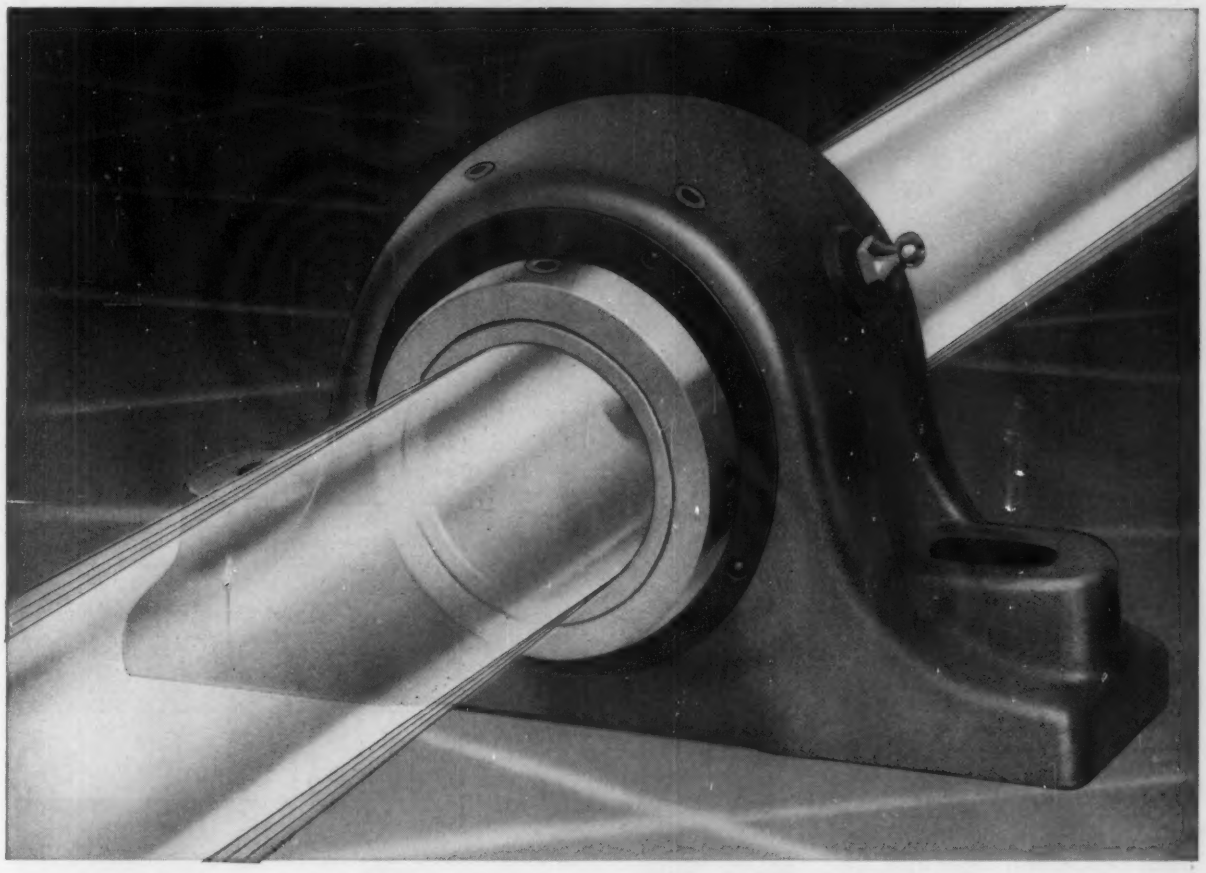
Aeronutronics has been studying self-organizing machines and advanced components since formation of the company in 1956. Development work on the MIND unit was supported by the Office of Naval Research Information Systems Branch, Washington, and Air Force's Rome Air Development Center. In part, operation of MIND is based on principles of BIAX computer elements.





A quarter the size of a penny, MIND, an artificial neuron or brain cell, can carry out learning processes. A simple nerve-net made up of a number of MIND cells can duplicate some of the decision-making functions of the human brain. Each MIND is composed of a toroidal magnetic core with an inner hole through which strobe wires are strung. The core is a ceramic ring capped with a metal washer and again wound with wires. Basic operation of MIND can be described in four steps: 1. Electrical pulse received by storage winding (the fact). 2. Residual flux remains stored in ceramic core (the memory). 3. Magnetic field created by strobe circuit (the question). 4. Readout receives output proportional to stored flux (the answer).

Free rolling . . . long lasting because it's *Self-Aligning*



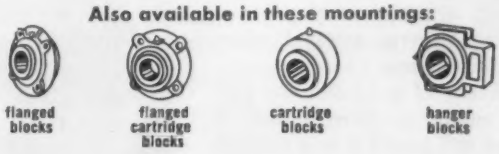
Link-Belt roller bearings compensate for misalignment of shafts and supports

Link-Belt Series 400 roller bearings have won a reputation as "the designer's choice." These self-aligning, double-row roller bearings compensate for inaccuracies in machining and assembly of equipment while maintaining full load capacity throughout their long life. Their compactness promotes simplicity of machinery design—their easy mounting reduces installation costs.

For complete information on the Series 400 —and Link-Belt's complete line of ball and roller bearings—send for our Book 2550. It's available at any one of the 40 Link-Belt offices.

Look under BEARINGS in the yellow pages of your phone book.

Also available in these mountings:



flanged blocks | flanged cartridge blocks | cartridge blocks | hanger blocks

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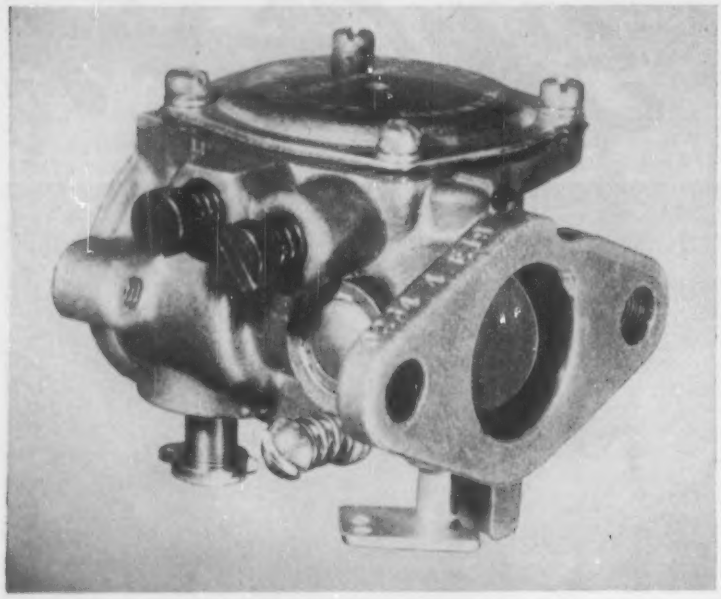
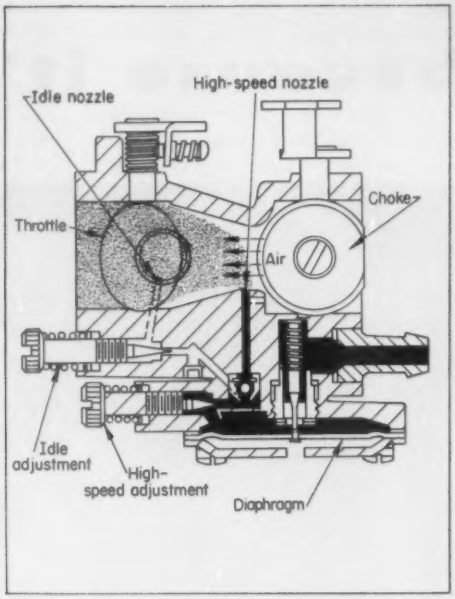
Carburetor Switch Stretches Small-Engine Mileage





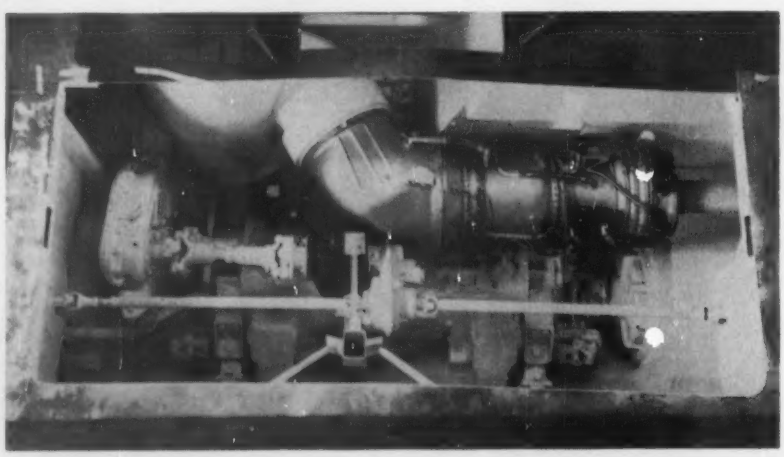
Even upside-down, a new aircraft-type carburetor for small engines is getting up to 20 per cent more mileage on a tank of fuel. Its design gives better engine performance, higher efficiency, and appreciably longer engine life. Instead of the conventional float chamber, this carburetor has a diaphragm, a spring-loaded inlet needle, and a reservoir located beneath the venturi. The diaphragm flexes under pressure variations within the throat, permitting only the necessary amount of fuel into the engine. This eliminates the need for overflow devices and permits the gas tank to be remotely situated. Further, no fuel pump is required except when the tank is situated below the engine. Power Products Div. of Tecumseh Products Corp., Grafton, Wis., will use their carburetor primarily for lawn mowers, power tools, and traveling machinery that encounters rough handling. Eliminating the float bowl, they point out, allows a mower to be tipped upside-down for cleaning without any flooding or leaking. It also minimizes the problem of vapor-lock.

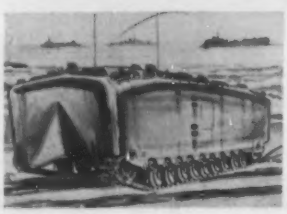
New Job for the Gas Turbine

SCHENECTADY, N. Y. — Thirty per cent higher speed and 5000 lb additional payload will result from converting a military amphibious landing craft to gas-turbine power, according to General Electric engineers. Weight of the powerplant-transmission package will be less than half of the equipment it replaces, and space occupied will be reduced by a factor of seven.

General Electric released these performance figures when announcing shipment of a Model 720 gas-turbine engine to Jered Industries Inc. Jered will install it in a refitted, experimental version of the Marine Corps LVTP-5 personnel and cargo carrier under development for the Navy.

Performance improvements are due to the compactness, light weight, and high efficiency of the turbine and a new transmission system engineered by Jered. Total weight of





Viewed through the engine-compartment hatch, the GE gas turbine is mounted athwart-ships, above and parallel to the transmission system. The engine occupies only 9 cu ft of space, as opposed to 65 cu ft for the conventional piston-engine powerplant. Total weight of the engine-transmission package is under 3200 lb; it replaces more than 6500 lb of equipment.

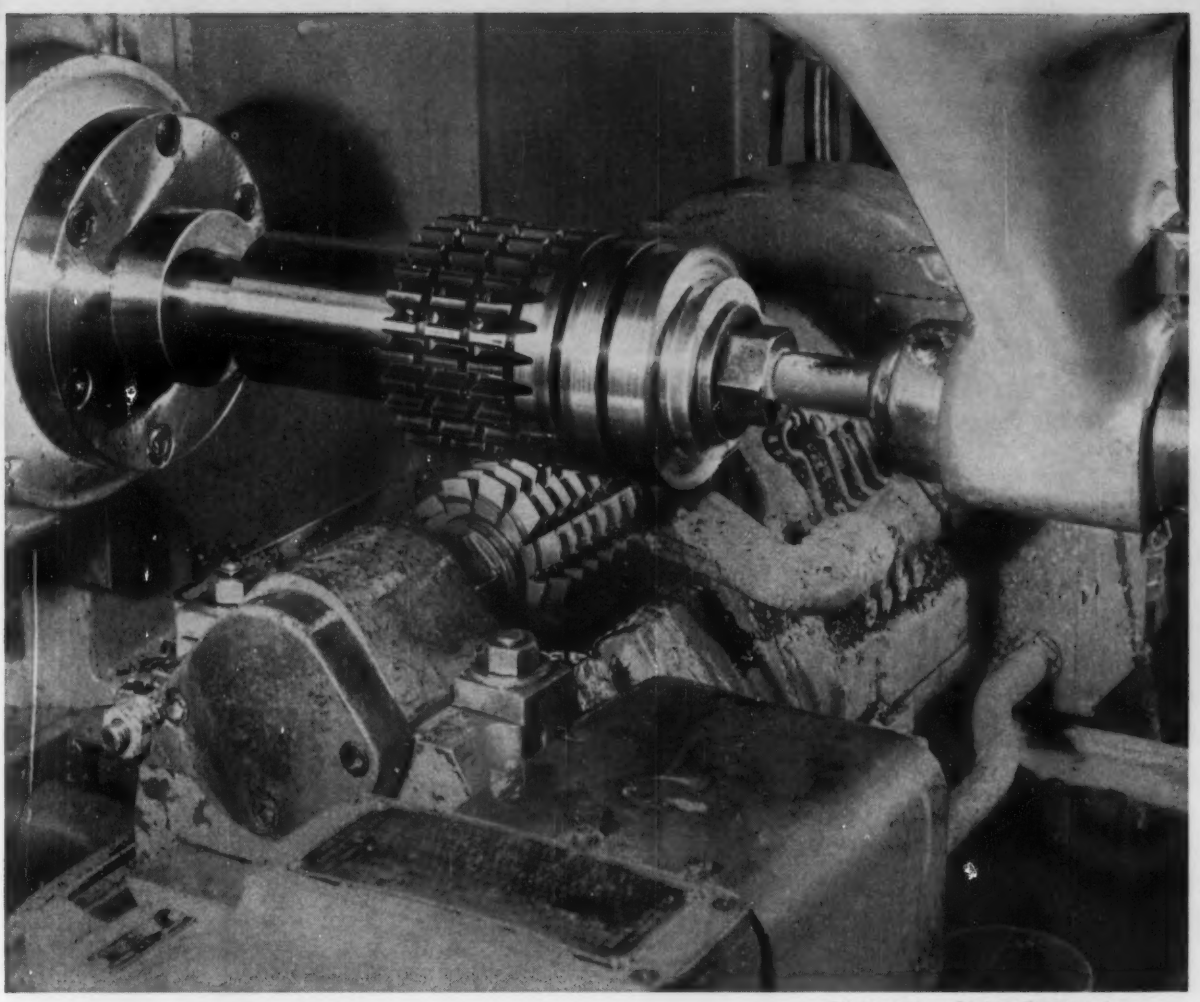


Photo courtesy Chelsea Products, Inc.

Aristoloy Leaded Steel provides free machining for Chelsea Products, Inc.

Steel for gears used in power take-off assemblies must have uniform hard surface, high tensile strength and yet machine freely. Aristoloy Leaded* users have benefited from these qualities.

Chelsea finds more gears can be cut from leaded Aristoloy before the hob needs sharpening. Production can be improved and speeds and feeds increased over non-leaded steel.

Strength and hardness are not affected and the finished part reveals no detectable difference in physical properties from steel previously used.

For complete information call the Copperweld representative in your nearest large city . . . or write today for New Products & Facilities Catalog.

*Inland Ledloy License

ARISTOLOY STEELS

DIVISION OF
COPPERWELD
STEEL COMPANY

ARISTOLOY STEEL DIVISION • 4017 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

the engine-transmission combination is less than 3200 lb, compared to 4500 lb for a piston-engine powerplant system. Space occupied will be 9 cu ft (down from 65 cu ft). Reduced size, combined with athwart-ship installation of the package, enlarges the amphibian's cargo volume by 210 cu ft (33 per cent).

Government Ups Priority On Materials Research

Will Finance $6 Million Research Center at Cornell

ITHACA, N. Y.—The cost of developing new materials is expected to jump several hundred-fold in the next four years. The Federal Council on Science and Technology announced a year ago that research in materials should be given higher priority. The Council further thought that progress could best be made by universities—the traditional seat of basic research.

Responsibility for setting up a logical program was assigned to the Advanced Research Projects Agency (ARPA), in June 1959. After a survey of universities interested in the program, ARPA has announced the signing of three long-range contracts. Ultimately ARPA expects to support materials research at the rate of $17 million a year. Initial contracts are for only $3.5 million a year, however, nearly all of it to be spent on equipment.

The largest contract, with Cornell University, is for $6 million over the next four years, to be used in establishing the Cornell Materials Research Center. The university has appointed Professor R. L. Sproull as director of the new center.

Initially, the Laboratory of Atomic and Solid-State Physics will comprise the greatest single part of the center. Scientists from the Department of Chemistry will also form a large part of the center, with both professors and graduate students working there.

Other contracts have been signed by University of Pennsylvania and Northwestern University for $4.4 million and $3.4 million respectively. Each of these agreements is for four years of materials research.

Powder Particles Perfectly Round

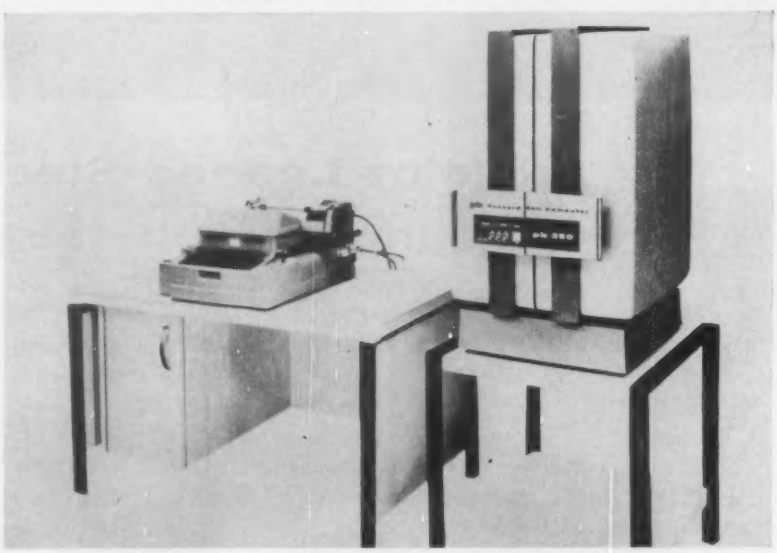
Magnified here about fifty times, spherical particles comprising a new line of metal powders have a uniformity rate of 98 per cent. Ranging in size from 20 to 50 microns, they are produced in a totally inert atmosphere. Starting material for the powders, says Union Carbide's Linde Div., is 1/16-in. wire of uniform cross section. The finished powders are free from voids, cavities, and inclusions, and when required, can be supplied free from surface oxidation. The company suggests a variety of uses:

- Improved solid-fuel rocket propellants. The addition of spherical aluminum powder will improve burning stability and produce significantly higher thrusts.
- Easier to handle highly reactive powders. Spherical particles offer the lowest possible surface-to-volume ratio, thus decreasing surfaces available for reaction.
- Improved sintered parts. Addition of about 20 per cent of spherical particles to an otherwise angular powder improves its flow properties, gives better quality parts.

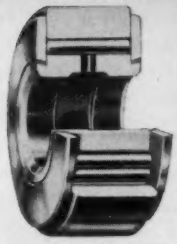
Because porosity can be controlled, better filters, porous piston rings and other sintered components can be produced.

The powders, available in limited quantities, are being produced of copper, aluminum, nickel, tungsten, and some steel alloys. Other materials can be prepared in this form as the need arises, and it is hoped that materials will soon be available with particle sizes below the present 20-micron limits.

Size and Cost Minimized in New Digital Computer



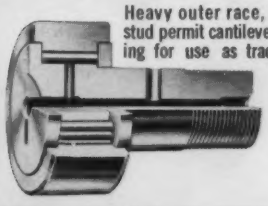
Designed for on-line or off-line applications, a new solid-state digital computer performs equally well as an engineer's desk-side assistant, or as an on-line computer for process monitoring, process control, data logging, and alarm generation. A serial, binary, single-address machine, it uses an internally stored program, has microsecond speed. Packard Bell Computer Corp., Los Angeles, who developed the $30,000 machine, claims it has capabilities ordinarily found in much larger computers ($200,000 plus). The PB unit has a memory of 1808 words (word = 21 bits plus sign) expandable to 15,888 words internally. Additional 16,384 words of core memory are available. Standard equipment includes automatic typewriter with paper-tape reader and punch. Full range of optional accessories are available, including magnetic tape units, analog-to-digital and digital-to-analog converters.



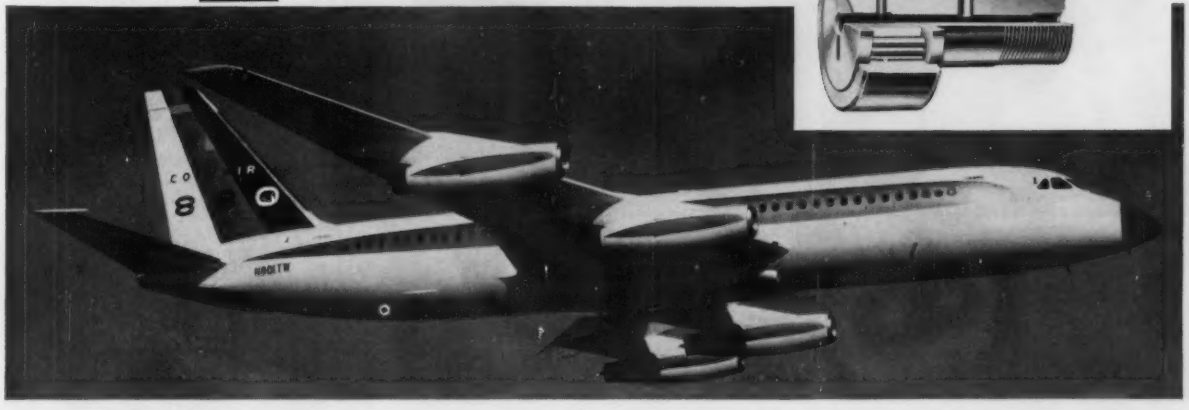
Extra heavy outer race for heavy rolling loads. Also available in double row type.

JET AHEAD WITH TORRINGTON BEARINGS–

ON ALL THE GREAT NEW JETS



Heavy outer race, integral stud permit cantilever mounting for use as track roller.



Specially designed to withstand heaviest rolling and shock loads, Torrington Track Rollers and Cam Followers are at the heart of take-off and landing procedure on all the new commercial jets.

Tremendous speeds and carrying capacity of jet aircraft impose heavier than ever loads on the flaps, yet their operation must be smooth, efficient, 100% sure. Torrington engineers developed larger, tougher track rollers and cam followers... bearings specially designed for performance and the utmost in dependable commercial jet service.

Track rollers and cam followers, compact and light in weight, offer maximum radial capacity in minimum cross section. A full complement of small diameter rollers insures minimum starting and running friction.

Torrington aircraft bearings are manufactured to the highest standards in the industry. For further information or application assistance, write or call Torrington—maker of every basic type of anti-friction bearing.

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY Torrington, Conn. • South Bend 21, Indiana

Sixth Mechanisms Conference Set for October 10-11

LAFAYETTE, IND.—After a one-year breather, leading authorities on mechanisms design and application will convene this fall on the Purdue University Campus for a two-day session.

Like the five preceding Conferences (the last was held in 1958), the sixth will be co-sponsored by MACHINE DESIGN and Purdue's School of Mechanical Engineering. It will feature the usual varied program, ranging from practical everyday application of mechanisms to advanced concepts in design.

Since its inception in 1953, the Conference has emerged as the principal meeting ground of its kind in the U. S. It is rivaled only by similar European conferences, and leading figures in the European groups invariably attend the Purdue-MACHINE DESIGN sessions, often as participants.

Complete details of the Conference will appear in the news pages of MACHINE DESIGN during the coming weeks.

Dialing Digital Data

If you're properly equipped, you can now phone-in your data and let "central" do the calculations—automatically. A new system developed by International Business Machines Corp. lets remote equipment converse with a centralized computer or business machine over existing telephone lines. Fixed data are fed from prepunched cards; variable information is added manually on a keyboard. Once contact is established with the remote location, the telephone at the computer end of the line punches transmitted data into cards automatically, with minimum operator attention. IBM claims the system will offer new operating economy and efficiency to every business with decentralized operations, regardless of size.

Mighty Fine Wire

Wire with a tensile strength of 575,000 psi has been produced by commercial methods. Over 4000 miles were made on the first trial run by National Standard Co., Niles, Mich. The wire, with 0.005 in. diam, is high-carbon steel (0.90 per cent carbon). Both military and civilian applications are expected.

Ground-Bound Astronauts Gain Re-entry Skills

DALLAS—Returning from "space" for about the four-hundredth time, a vehicle makes its lunar re-entry at 2500 mph and slows by dipping into the earth's atmosphere. Outgrowth of more than a year and a half of research at Chance Vought Astronautics Div., such lunar-mission "re-entries" are being accomplished almost daily with an intricate space-flight simulator that never leaves the ground.

The simulator looks like the cockpit section of a one-man space ship and it has an impressive array of instruments suitable for missions in space. A roomful of computers, including 350 amplifiers and 10,000 vacuum tubes, calculates the ship's responses to the pilot's control. Results are reflected in gages showing rocket thrust, fuel level, vehicle temperature and attitude, gravity forces and vehicle speed. Four plotters and 18 recorders plot each flight to provide a record of the pilot's progress

Characteristics for the simulator have been taken from a winged craft of triangular shape having a high lift-drag ratio. In "flying" it, the pilot must avoid plunging too deeply into the earth's atmosphere and overheating, or grazing the atmosphere too thinly and skipping out into a new orbit. In the former case, the plane would burn up, and in the latter case it may have to wait up to five days in orbit before it has another chance at re-entry.

The division is planning simulators for more advanced missions. One new model, now in the planning stage, will be of a maneuvering type to improve the pilot's appreciation of the vehicle's attitude. Projected earth, horizon, and star displays will give him a realistic look at outer space and provide new visual references.

The company believes that simulation will play a major role in space training. J. R. Clark, general manager of the Astronautics Div. comments, "Unlike the aircraft pilot, the first space pilot will have no dual instruction and little step-by-step flight training to prepare him for his mission." He will be faced with all the problems of outer space on his first mission and he must be right, or he is lost.

Topics

We all don't have to scream for ice cream any more—all it takes is the push of a button. Punched cards are the "recipes" from which electronic equipment measures out proper amounts of ingredients from storage and mixes them, pasteurizes, homogenizes, and cools the ice cream. Cleaning of lines, valves, and tanks is also done automatically. The equipment, engineered by Brown Instrument Div. of Minneapolis-Honeywell Regulator Co., is being used by H. P. Hood & Sons in Boston.

• • •

Oil that doesn't mix with other oil, but stays underground in a jellied form, may be extracted by an oil-well heater being developed by Raytheon Co. The heater uses special electronic generators in the microwave band; microwaves emitted are expected to provide quick-acting, penetrating heat to make the oil flow. If the Raytheon heater works, it has a busy future—some 180 billion barrels of oil in the U. S. are inaccessible to conventional equipment.

• • •

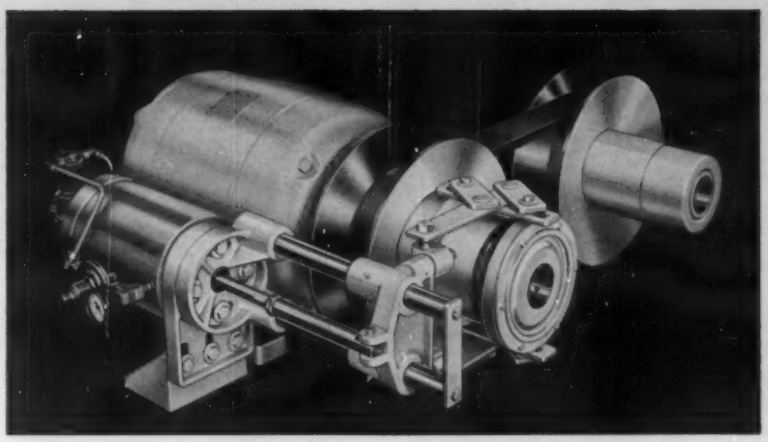
Pen pal: While others have been worrying through designs of writing instruments for use under water and on buttered paper, a practical German fellow developed a ball-point pen which carries writing paper rolled up in the barrel.

• • •

Expendable epidermis of a new plastic coating protects missile and launching-pad components usually destroyed during firing. The coating, developed by Dyna-Therm Chemical, forms a hard ceramic crust which lifts away, providing additional insulation. Able to withstand direct heat up to 6000 F, the coating consists of phosphates and boron compounds with a polyurethane binder.

• • •

Umpire's best friend may turn out to be a TV equipment setup invented by Lloyd F. Knight, manager of engineering services for Servo Corp. of America. Cameras flanking the batter (to provide the best view of both right and left-handed players) and another camera located overhead will show both the ball's height and whether it passes over the plate. The umpire watches a monitor and can replay a tape record of any pitch which is disputed. In addition to accuracy, an advantage of the electronic equipment is that it gets the umpire out of the way of the ball and the catcher. Cameras could also be set up in the stands to help an umpire judge whether a runner is safe or out.



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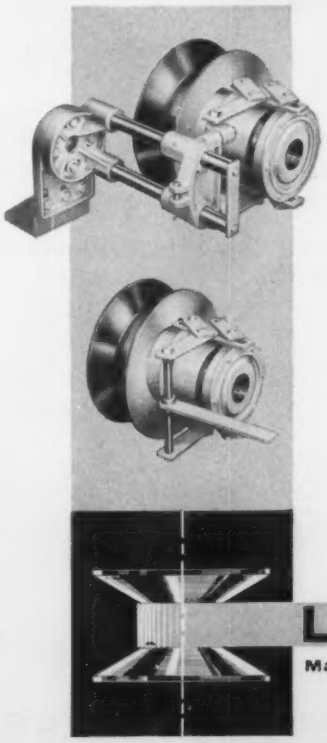
VARIABLE SPEED PULLEYS
AUTOMATICALLY CONTROLLED
WITH PNEUMATIC REGULATOR

Pneumatic regulator mounts adjacent to motor, and connects with Adjustable Pulley to vary speeds smoothly over a wide range.

The regulator is controlled from process instruments, and responds precisely to a signal range of 3 to 15 psi.

The speeds obtained conform accurately to signal pressure changes. Speeds are varied, maintained, or repeated with the signal pattern.

Here is a method for controlling the process continuously, using the readily automated flexibility of variable speeds.



Adjustable Pulley equipped with lever shifter and operator for mounting pneumatic, hydraulic, or mechanical regulator.

Adjustable Pulley equipped with lever shifter for any motion control.

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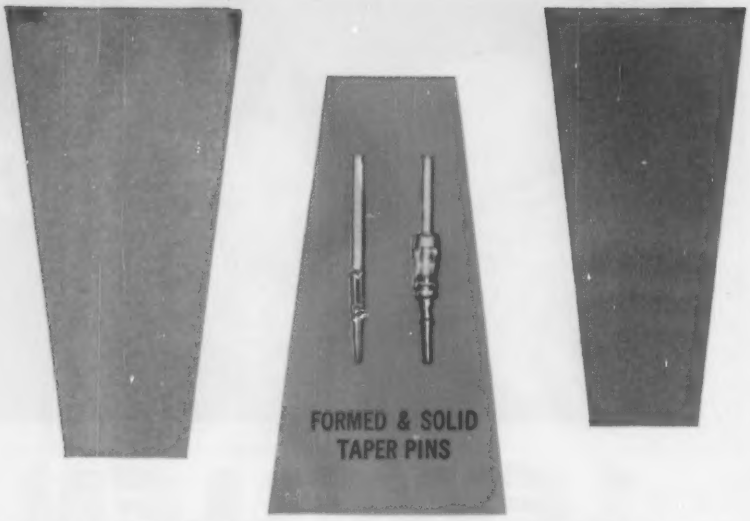
Manufacturing Company, Columbus, Indiana

Distributors in all Industrial Areas

Circle 411 on Page 19



FOR A TIGHT FIT IN A TIGHT SPOT...

If miniaturization has put your circuits in a tight spot, you can build reliability right into them with the AMP Taper Technique . . . formed taper pins or new solid, pre-insulated taper pins . . . two-piece or molded one-piece stackable blocks . . . plus a wide assortment of taper receptacles.

The AMP Taper Technique offers the most complete line of taper products available plus many extra features. A three-and-a-half degree taper assures the firmest fit of pin in block. A-MP Pull-Test Insertion Tools assure the proper seating of pins. Hand and Automachine crimping tools assure uniformity of pin attachment to your circuit leads.

And—with the addition to the AMP Taper Technique of the new Solid Pre-Insulated Diamond Grip Taper Pin and the new one-piece warp-free block, you can have the greatest flexibility of product choice for your circuit design and manufacturing operations.

You can concentrate more circuits in a smaller space—and be sure of reliability when you use the AMP Taper Technique. Send for our new catalog today.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

Circle 412 on Page 19

Reader Information Service

SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

Acceleration, Edit. 151
Adhesives, Edit. 179, 188
Alloys, high-temperature, Adv. 42
Aluminum and alloys, Adv. 167
Amplifiers, Edit. 172
Axles, Adv. 77

Balls, Adv. 39, 184
Bearings,
  ball, Adv. 9, 21, inside back cover
  miniature, Adv. 177
  roller, Adv. 9, 13, 21, 56, 78, back cover
  sleeve, Edit. 180; Adv. 197, 207, inside back cover
Belts, transmission, Adv. 54
Blowers, Adv. 161
Books, Edit. 196
Brakes, Edit. 137, 172, 199, 202; Adv. 59, 60, 173, 203
Brazing alloys, Adv. 38
Bushings, Adv. 44
  ball, Adv. 193

Cam followers, Adv. 43
Carbon and graphite parts, Adv. 157
Carriers, Adv. 204
Castings,
  centrifugal, Adv. 194
  nonferrous, Adv. 58, 158
Chain,
  conveyor, Adv. 75
  transmission, Adv. 75, 191
Clamps, Adv. 182, 209
Clutches, Edit. 172, 199; Adv. 59, 60, 169, 173
  electromagnetic disc, Edit. 113
Coatings,
  decorative, Adv. 65
  protective, Edit. 22, 163; Adv. 64, 204
Controls,
  hydraulic, Adv. 27, 76, 210
  mechanical, Adv. 165
  pneumatic, Adv. 100
Counters, Edit. 142; Adv. 181
Couplings,
  fluid flow, Adv. 155
  shaft, Edit. 189; Adv. 170
Cylinders,
  hydraulic, Adv. 40, 62, 71, 97, 183
  pneumatic, Adv. 40, 62, 71, 97

Design handbook, Edit. 104
Designing with vinyls, Edit. 147
Diaphragms, Adv. 178
Drafting equipment, Edit. 194, 195; Adv. 45, 87, 93, 208
Drafting techniques, Edit. 135
Drives,
  adjustable speed, Edit. 176, 183; Adv. inside front cover, 168
  magnetic, Adv. 204

Electric equipment (see specific type)
Electronic equipment, Edit. 34, 109, 136; Adv. 99, 184
Engineering department (see Management or Drafting)
Engineers, Edit. 22, 39, 40
Engines, Adv. 89, 176

Fans, Adv. 98
Fasteners,
  bolts, studs, screws, Adv. 81, 84, 96, 160
  insert, Edit. 175
  nuts, Edit. 172, 186; Adv. 80, 163, 192
  pin, Adv. 16, 210
  quick operating, Edit. 179; Adv. 55, 91
  stud, Adv. 91
Felt, Adv. 209
Filters, Adv. 88
Finishes (see Coatings)
Fittings, pipe, tube, and hose, Adv. 33
Forgings, Adv. 83

Gages (see Instruments)
Gaskets, Adv. 41
Gears, Adv. 72, 73, 195, 203

Handles, Edit. 192
Heaters, Adv. 170
Hydraulic equipment (see specific type)

Instruments, Edit. 111, 143, 184, 200; Adv. 189, 205, 209

Jacks, worm gear, Adv. 166

Karts, power behind, Edit. 24

Locks, Adv. 198
Lubricants, Adv. 92
Lubrication, systems, Adv. 82

Meetings, Edit. 40
Metals (see specific type)
Modular design, Edit. 153
Motors (electric),
  fractional and integral hp, Adv. inside front cover, 1, 98, 171
  gearmotors, Adv. 66
  subfractional hp, Adv. 69, 179
  synchronous, Edit. 189
Motors, torque, Edit. 178

Nickel and alloys, Adv. 63

MACHINE DESIGN is indexed in the Applied Science & Technology Index and the Engineering Index, available in libraries, generally. Microfilm copies are available from University Microfilms, 313 N. First St., Ann Arbor, Mich.

Packings, Adv. 31
Plastics, Edit. 36, 184; Adv. 65, 67, 68, 180, 213
Pneumatic equipment (see specific type)
Programing, Edit. 138
Pulleys (see also Sheaves), Adv. 15
Pumps,
hydraulic, Edit. 141, 186, 202; Adv. 35, 48, 76, 78, 168, 207
pneumatic, Adv. 202

Radiation, Edit. 39
Rectifiers, Edit. 191
Reducers, speed, Edit. 191
Regulators, pressure, Adv. 206
Relays, Adv. 79
Rubber, Adv. 70

Screws, power, Adv. 186
Seals, Edit. 193; Adv. 31, 160
Shafts, Adv. 77
Shapes, special, Adv. 188
Sheaves (see also Pulleys), Adv. 206
Silicones, Edit. 192, 193; Adv. 49, 204
Slider-crank whip, Edit. 144
Sprockets, Adv. 75
Starters, motors, Adv. 101
Steel, Adv. 7, 11, 52, 57, 83, 214, back cover
stainless, Edit. 27, 178; Adv. 29, 95
Switches, Edit. 112, 180, 182, 200; Adv. 46, 47, 53, 79, 175, 201, 207
Systems, hydraulic, Adv. 51

Terminals, Adv. 2
Thermal stresses in design, Edit. 129
Thermostats, Edit. 188; Adv. 94, 156, 208
Timers, Edit. 172
Transducers, Edit. 36, 110
Transformers, Edit. 183
Transistors, Edit. 30
Transmissions, adjustable speed, Adv. 209
Tubing, Adv. 5, 29, 74, 95, 187, 205

Valves,
hydraulic, Edit. 201; Adv. 85, 102, 159, 199, 203, 205
pneumatic, Edit. 175, 198; Adv. 86, 100, 102, 200
Vibration isolation design, Edit. 123

Welding, Adv. 50
Wire and wire products, Adv. 37, 90

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CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

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Index to New Parts & Helpful Literature
BY ITEM NUMBERS

HELPFUL LITERATURE— descriptions start on page 164

	ITEM NUMBER
Adhesives, Coatings, Sealers	601
Small Servo Motor	602
Recording Oscillograph	603
Switches and Thermostats	604
Silicones in Appliance Design	605
Sequence Programmer	606
Seamless Strip-Tubing	607
AC Motors	608
Molded Coil Bobbins	609
Coatings Selector	610
Clutches and Differentials	611
Power Transmission	612
Fabrication of Teflon	613
Industrial Clamps	614
Screw Threads	615
Magnifying Comparator	616
AC Motors	617
Nickel-Chromium Alloy	618
Window Units	619
Speed Reducers	620
Steel Tubing and Bars	621
High-Temperature Fasteners	622
Screw Conveyor Drives	623
Steel Pipe	624
Basic Switches	625
Special-Purpose Fasteners	626
Gate Valves	627
High-Strength Insert	628
Relief Valves	629

NEW PARTS & ENGINEERING EQUIPMENT— descriptions start on page 172

	ITEM NUMBER
Press-In Nut	630
Slip Clutches and Brakes	631
Servo Amplifier	632
Reset Timer	633
Collar Insert	634
Directional Valves	635
Adjustable-Speed Drives	636
Color-Coated Stainless Steel	637
Stepping Motor	638
Epoxy Adhesive	639
Panel Fastener	640
Mercury Switch	641
Pillow-Block Bearings	642
Toggle Switches	643
Adjustable-Speed Drives	644
Electrical Transformer	645
Epoxy-Resin Compound	646
Temperature Detector	647
Blind-Mounting Lock Nut	648
Self-Priming Pump	649
Fast-Drying Adhesive	650
Insulated Thermostat	651
Flexible-Shaft Couplings	652
Synchronous Motor	653
Speed Reducer	654
Silicon Power Rectifiers	655
Cabinet Handles	656
Silicone Rubber	657
Silicone Additive	658
Teflon Dry Seal	659
Lead Dispenser	660
Drafting Tables	661
Copying Machine	662

MACHINE DESIGN
Aug. 4, 1960

Circle item number for information on products advertised or described or copies of literature.

401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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Page No. — Title of Article

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401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
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418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
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423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
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425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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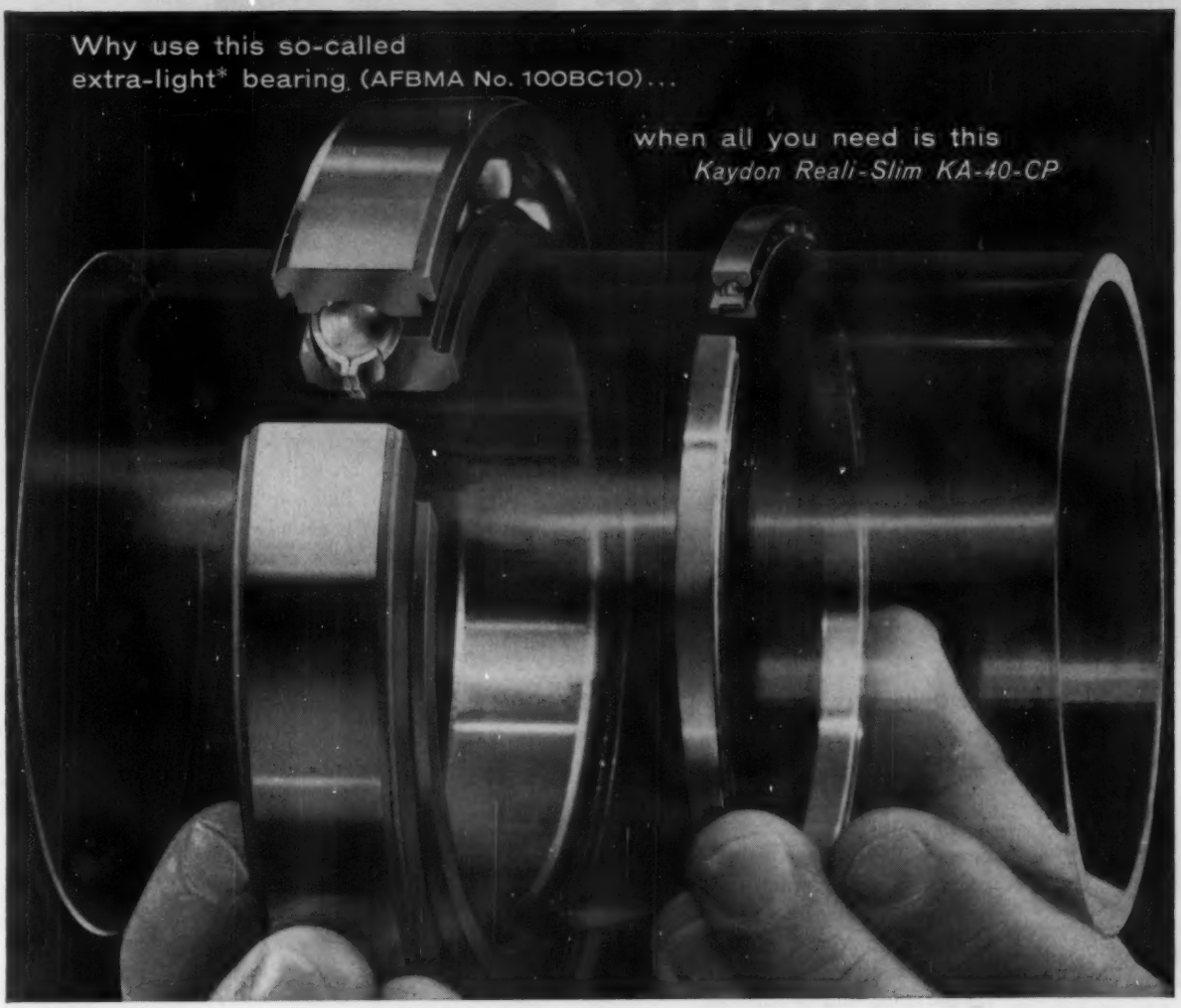
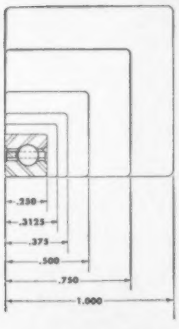


News from Kaydon!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%



*Five of the six series of Type "CP" Reali-Slim bearings are smaller in cross section than the AFBMA standard "extra-light" series bearing shown above.

Up to 85% lighter, up to 70% narrower than the lightest of the "extra-lights"

More than 80% of all present standard "extra-light" series bearing installations never require the full capacity of the bearing.

Kaydon now trims this expensive bearing excess! Kaydon Type "CP" Reali-Slim bearings match proper size, weight and capacity to specified shaft sizes. Overcapacity need no longer hamstring your product designs.

Here's why! In Kaydon's new Type "CP" Reali-Slim bearings (world's thinnest), width and cross section *remain the same* for all bearing sizes in any one series.

Example: each of the 15 sizes from 4" to 12" bore in the Reali-Slim KA series has only ¼" width and cross section. Result: new opportunity to save on cost, size, and weight . . . in bearings and adjacent components.

Availability? Now off-the-shelf in 90 sizes with Conrad deep-groove, ball-radial construction . . . and new bronze one-piece snap-over separator in 4" to 12" bore — ¼" to 1" width and cross section. Kaydon's volume production cuts prices as much as 76%, depending on size. Write for free, fact-filled "CP" bearing bulletin — with prices!

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K-160

Circle 413 on Page 19

in union there is . . .

Better pay, but room for improvement in working conditions . . . this, according to a recent survey, represents the composite opinion of engineers who belong to unions. The study, conducted by Professional Engineers Conference Board for Industry, disclosed that a large percentage of unionized engineers were happy with their pay, thought it to be higher than that of comparable non-union professionals. However, there was general agreement (among those who administered the survey) that preoccupation with salary level to the exclusion of other professional working conditions had convinced the union members that they were better off financially than is actually the case. In the matter of working conditions, company employment practices, etc., union engineers were noticeably less satisfied than non-unionists.

NBS works out tungsten-plating process

High-speed vapor deposition of tungsten—one of the few metals with acceptable strength above 3600 F—is a significant new NBS-developed technique for plating metal or ceramic shapes. Bureau scientists W. E. Reid and A. Brenner say that vapor deposition (from gaseous tungsten hexafluoride) may be the only way that complicated tungsten parts can be formed. The process, which requires only simple equipment, is fast—up to 1/16 in. per hr vs. 0.001 in. by conventional electro-deposition. NBS says that vapor-deposited-tungsten parts and plating allow designers to make use of high-temperature properties of the pure refractory metal without being stymied by its hardness and brittleness.

new threat to magnetic secrets

More knowledge on magnetism is coming: A national research center, soon to go up at Massachusetts Institute of Technology, will house the world's most powerful magnet (250,000 gauss) and other tools designed to pry loose nature's best-kept secrets. With this equipment, physicists will try high magnetic field experiments with atoms and atomic particles and study magnetism of the sun and planets. Major advances are predicted in the understanding of magnetic forces.

one-step program yields Ph.D.

Freshmen at Polytechnic Institute of Brooklyn can now try their hands at attending classes for six years and earning a doctorate directly. No strict dividing line separates graduate from undergraduate work; special curricula, seminars, and research projects start early. According to Dr. Ernst Weber, Polytechnic president, the program is designed for "the exceptional student whose full potential is not adequately challenged by the average college curriculum." For the first two years, mathematics, physics, and the humanities will be stressed. Specialties, offered in the third year, will include chemical, civil, electrical, mechanical, and metallurgical engineering.

no-strings research money

Universities are now receiving federal research money to use as they see fit. A significant change in government policy (previously, grants have been for specific projects only) has provided over $2 million in recent weeks to help 54 schools build or rebuild labs and buy new equipment. While hardly more than a drop in the bucket compared to other university-research grants, the science-for-science-sake money could add up to as much as $15 million during the next fiscal year. Concern about obsolescence of college-centered basic research has been growing ever since the President's Science Advisory Committee reported (about a year ago) that "a lack of instruments and facilities is beginning to handicap our national scientific effort in both government and private laboratories."

aeronautical—an archaic word

The A in IAS (Institute of Aeronautical Sciences) is being overhauled. The Institute's council recently voted to substitute "Aerospace" for "Aeronautical" and the change is now up for vote by the membership. It was felt that the old title was no longer consistent with the Institute's professional objectives and activities. In 1932, when IAS was formed, "aeronautical" was a hot word. Today the roster includes scientists and engineers working on flight at all speeds and altitudes and, in fact, space-project specialists nearly outnumber those working on earth-atmosphere flight.

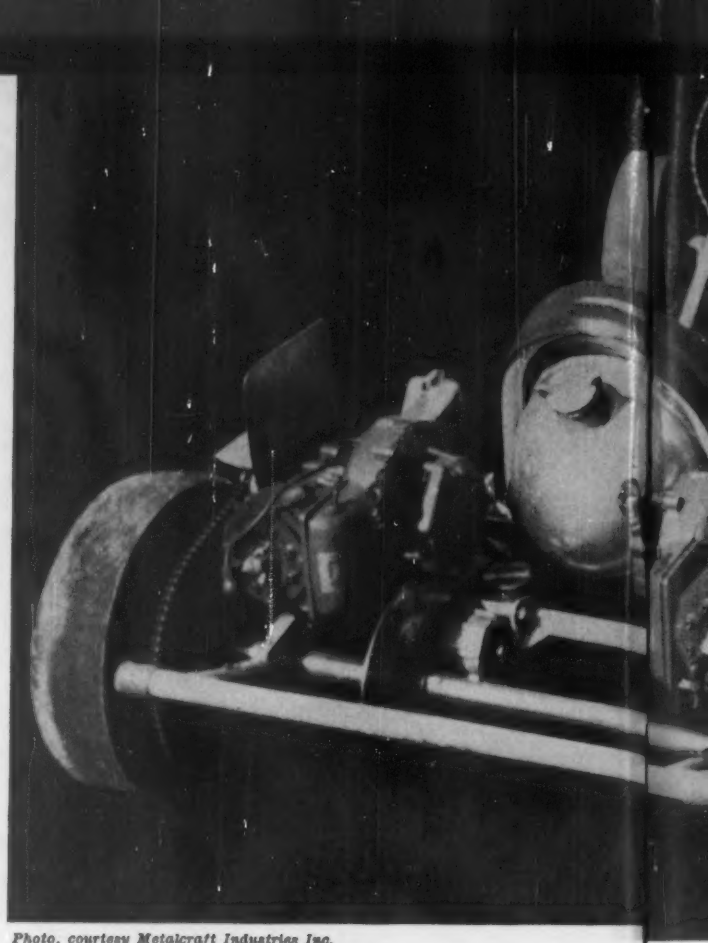
in space, a different man

A new twist has been added to the problem of preparing man for the mental and physical peculiarities of space travel. Instead of equipping spacecraft with complete facilities to duplicate or compensate for the lack of gravity and earth-like environment, the idea is to modify man to make him more adaptable to space conditions as they are. A report recently submitted to USAF's Aerospace Medical Center by a group of human factors experts, suggests that this could be done by radically lowering the subject's body temperature, by conditioning and hypnosis, and by using drugs administered through a closed-loop servo system tied to the space environment. The astronaut would thus gain a feeling of complacency, and specifications for the spacecraft's artificial environment could be greatly relaxed.

first degree (B.S.) in communication

Undergraduates at the University of Michigan can elect a program in communication sciences for the first time this fall. Concerned with machine encoding, electronic memories, mechanical translators, etc., the curriculum has until now been offered only to graduate students in the U. S. But the demand for trained people hasn't been met by graduate schools, says UM. Besides being well grounded in mathematics and electronics, students choosing this career must be trained in speech, linguistics, physiology, and language philosophy.

Power Behind the Karts



Photo, courtesy Metalcraft Industries Inc.

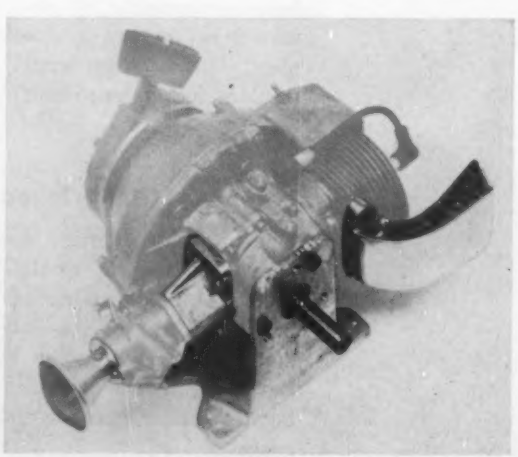
DISCARDED lawnmower engines are a thing of the past in the sophisticated karting world. The high-speed enthusiasts who thrive on low power have prodded leading manufacturers of small gasoline powerplants into performing some amazing design feats on the old two-cycle engine.

Before the karting boom (an estimated 250,000 of the "minimum" vehicles will be manufactured this year), most small-engine makers built a fairly standard line. For specific applications, they made proper compromises, much like Detroit's automakers do.

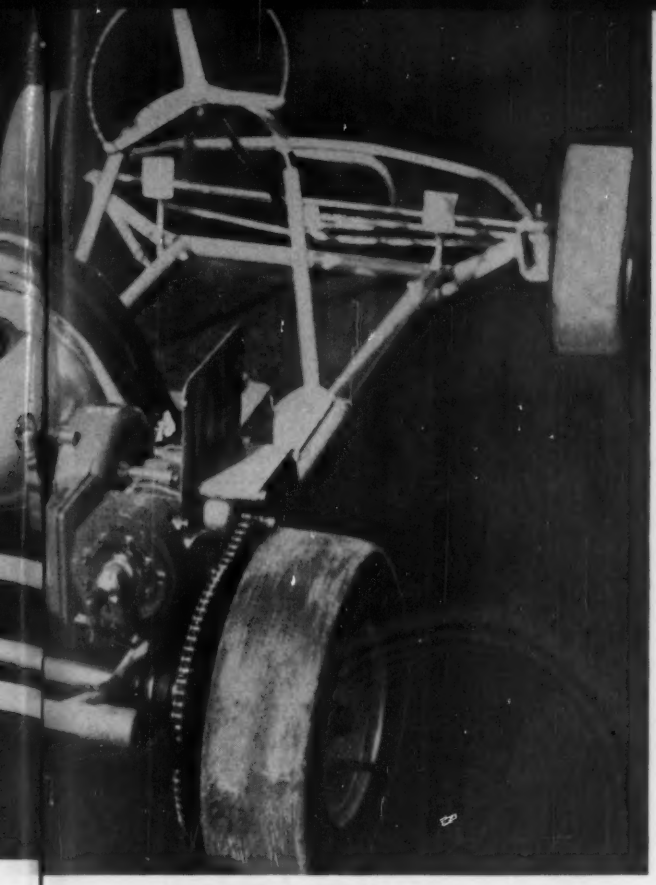
Then came karting . . . and the same intellectuals that pry 350-400 hp out of a flat-head V-8 went to work on the noisy, but innocent, two cycle. They had to call for help. Most two-strokers were not designed with modification in mind: Cylinders are one-piece assemblies (milled from the bottom up) and valving is virtually unchangeable, as are most of the carburetors.

Complaints by the frustrated speed merchants were received with calculated indifference by most of the engine manufacturers. Karting, to the latter, had all the earmarks of a motorized hula-hoop fad.

The neglect proved to be short-lived, however. A pyramiding market potential began to sway the judgment of some prominent names in the small-engine field, and engineering departments were finally instructed to turn a sympathetic ear to the problem. Since many designers were already dedicated karting fans, new-product development progressed at a startling rate.



Fully modified for competition, this early kart engine displays a full complement of chromed accessories. Merits of tuned exhaust header and ram-air stack are now questioned by experienced karters, who claim that at go-kart speeds, ram-air inlet would have to resemble the big end of a tuba to accomplish supercharging. They consider the tuned header to be an efficient device for "improving" engine noise.



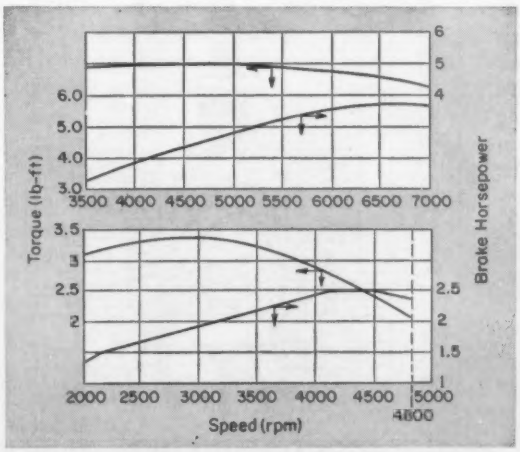
. . . resembling standard two-strokers in theory only, go-kart engines represent a significant advance in the state of the art

Severed Heads

First order of business was to satisfy the go-karter's heartfelt desire to tinker with compression ratios. Accordingly, one-piece cylinders quickly gave way to bolt-on head arrangements . . . and guarantees accompanying the engine were altered to state clearly that this design innovation was for convenience only, not a suggestion that further metalworking was needed. As expected, go-karters have responded by milling an acceptable 1/32 in. off the head — a move that produces upwards of 200-psi pressure in the cylinder (@TDC, before ignition), compared to a factory-rated 140-160 psi. A respectable chainsaw engine produces 90-120 psi.

Fine Art of Scavenging

Next big problem in tailoring two cycles for competition was improvement of the fuel-induction system. In the usual (cross-scavenged) two-cycle engine, there are only two ports in the cylinder wall. These



Flat torque curve of a karting engine (above) contrasts sharply with performance of the typical two stroker (below). Engines are of equal displacement; the kart powerplant, built by Power Products Div., Tecumseh Products Corp., weighs 12¾ lb vs. 15¾ lb for the more sluggish garden-variety engine.

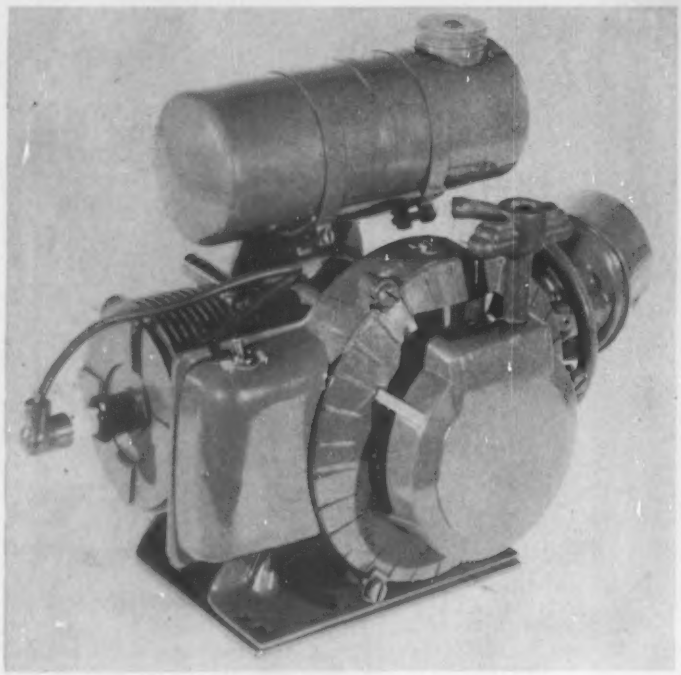
Kart Kronology

Karting really got started about four years ago as the result of a major lawn mower maker's dilemma (massive engine inventory that had to be liquidated). This, coupled with the fact that many people apparently will jump at a chance to own a racing car when it costs a mere $100, started karting on the road to success.

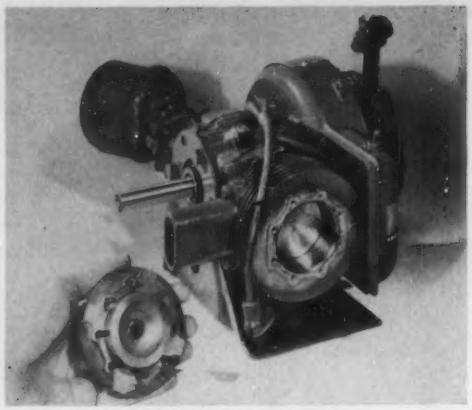
Fortunately, as the sport grew in popularity, a number of sane and enlightened people (mostly engine and kart manufacturers) emerged as a guiding force and formed the now influential Go Kart Club of America. GKCA wisely chose to stick with the two-cycle engine because of price, weight, and performance factors, and because it defies expensive hop-up treatment.

Rules have been set up by GKCA governing engine size and kart design. In the engine category: Class A—includes engines which displace up to 5.8 cu in. Class B—up to 11.6 cu in., created the twin-engine kart which is fast (about 50 mph), expensive, and sometimes unreliable. Rules governing kart design include, among other things, a specification that tread width be at least 2/3 of wheelbase.

Since chassis design is elementary (welded tubular steel), emphasis immediately centered on engine performance. Major engine manufacturers have responded with special racing versions of the two-stroke engine, and several manufacturers now have racing teams (as do Ferrari, Jaguar, et al) to take advantage of the prestige that accompanies a winner.

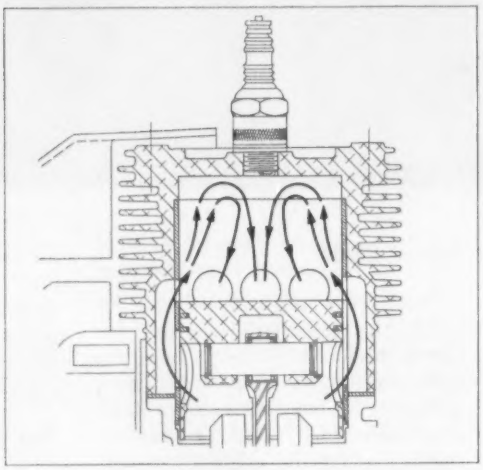


One of a new generation of two-cycle engines—a diminutive, high-performance powerplant designed especially for kart racing. Rated at 5.5 hp, it weighs just 12¾ lb. Its lone cylinder is die-cast aluminum alloy with a cast-in, cast-iron liner; piston is also aluminum, crankcase is magnesium. Bolt-on cylinder head is easily removed for modification of compression ratio. Piston rings (two, compression) are pinned to keep them from separating from the piston at high rpm and snagging in the oversize inlet and exhaust ports. Loop scavenged and diaphragm carbureted, the engine was designed by Power Products Div., Tecumseh Products Corp., Tecumseh, Mich.

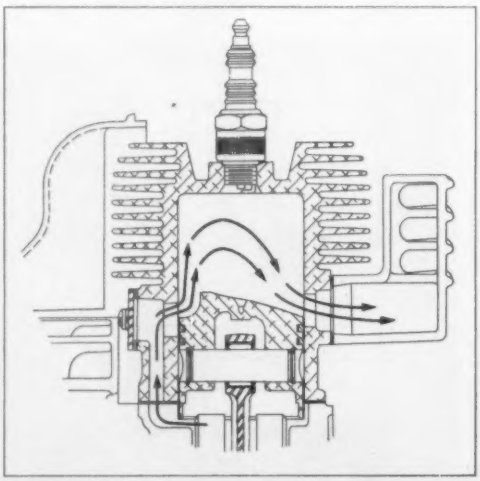


SPECIFICATIONS

Bore & Stroke (in.)	2.09 x 1.68
Displacement (cu in.)	5.80
Compression Ratio (approx.) .	7.5 to 1
Power, max (bhp)	5.5 @ 6400
Torque, max (lb-ft)	5 @ 3500



Loop scavenging (above) is a major factor in boosting two-cycle engine performance. Loss of unburned fuel is minimized, and turbulence, created by colliding fuel charges, efficiently scours out the remains of previous combustion. Ordinary two-cycle engines use less efficient cross scavenging (below).



are diametrically opposed, with the exhaust port slightly higher on the cylinder wall than the inlet port. As the piston completes a downstroke, and ports are uncovered, the incoming charge of fuel tends to rush directly across the cylinder and a portion of the new charge continues on out the exhaust. This action also results in poor scavenging of the combustion by-products, particularly in that portion of the cylinder above the upper lip of the exhaust port. Incoming fuel is polluted (and diluted) by the remains of the previous charge, making it less explosive, and reducing the efficiency of the engine.

"Loop scavenging" solves this problem in the latest karting engines. Two opposing inlet ports are used, and the two incoming jets of fuel collide, setting up a turbulence that forces clean fuel into all parts of the combustion chamber. This efficiently scours out the leavings of previous combustion.

Easing the Fuel Shortage

Carburetion was the last major obstacle. Automotive float-type metering devices which work fairly well on a lawn mower don't provide a sure-fire source of fuel to a kart engine traveling at forced draft on rough terrain and around curves. Most kart engines are now equipped with so-called aircraft-type carburetors which incorporate a vacuum actuated diaphragm metering device. The engine gets a constant flow of fuel at any angle and speed.

Basic Data Developed On Weldability of Stainless

Common Alloying Elements Aren't Always the Best

PITTSBURGH — New "seasonings" have proved so successful in the lab that metallurgists are now testing 1-ton quantities of stainless steels made from experimental recipes. They hope to eliminate the drawback which most often plagues stainless: Its tendency to fissure and crack under the heat and stress of welding.

In the work, conducted at Westinghouse Electric Corp., the basic stainless studied has been an austenitic steel containing 16 per cent chromium and 20 per cent nickel. Concentration of base elements and 16 alloying elements has been varied tc determine exact quantitative effects of each. Results show that some of the traditional alloying agents may be part of the trouble:

- Titanium and columbium, two of the most commonly added stabilizing agents, are among the worst in promoting hot cracking.
- Boron and zirconium, often added to increase strength, ductility, and workability, cause the most extensive cracking damage of all elements tested.

Other common alloys seem all right:

- Manganese decreases hot-cracking susceptibility; substantial amounts of manganese greatly increase weldability.
- Molybdenum and tungsten, often added to increase strength of the steel, also increase weldability.
- Vanadium, also added to increase steel strength, has no effect on weldability.
- Tantalum, a metal that's as good as titanium and columbium in stabilizing steel and improving its strength, does not increase hot cracking nearly as much as the other two.

New steels developed under the Westinghouse formula, called Kromarc steels, are described as high-temperature, high-strength, high-ductility, and super-weldable stainless steels.

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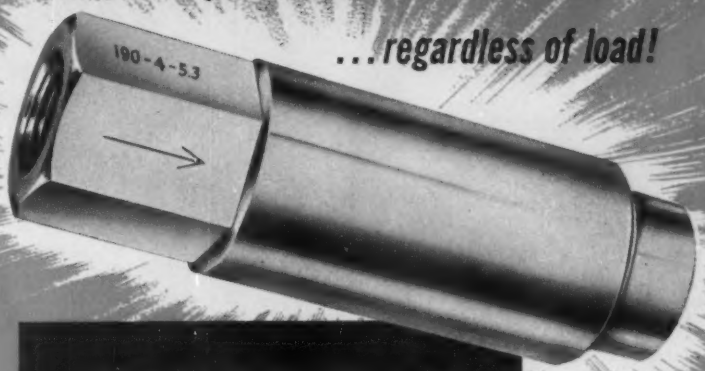

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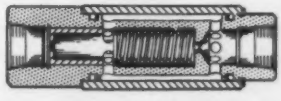

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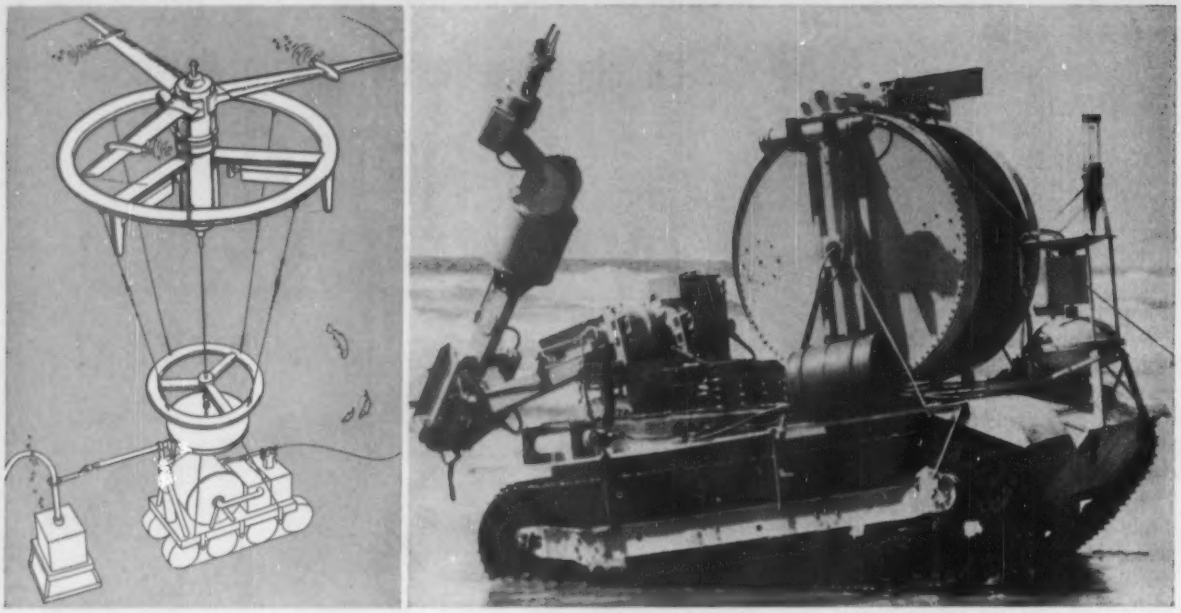
WATERMAN HYDRAULICS CORPORATION

WATERMAN HYDRAULICS CORPORATION • 725 Custer Avenue, Evanston, Illinois

Circle 414 on Page 19



Engineering design for fully operational RUM includes an "underwater helicopter" (left) which will enable the deep-sea tractor to "swim" underwater, rather than just crawl along. The helicopter will raise or lower RUM, move it sideways, hover or float it. Tracks on the vehicle (right) incorporate a spring-actuated friction brake for emergencies.

RUM

Navy's remote-controlled undersea explorer has 4/5 of the earth's surface to itself

WASHINGTON—An experimental vehicle that may give man full freedom for scientific investigation of the ocean floor is undergoing tests for the Office of Naval Research. If recommendations of a number of government bodies that have been studying the oceanographic research program are heeded, the strange vehicle may soon be mass-produced.

RUM (for Remote Underwater Manipulator) is essentially a tank mounted on crawler tracks and equipped with a manipulator hand and arm. Signals from television and sonar scanners are transmitted to a mobile van on shore by a cable long enough to permit operations at distances up to five miles. The cable also relays power for the tractor's two electric motors. It will probably cost more than the test vehicle.

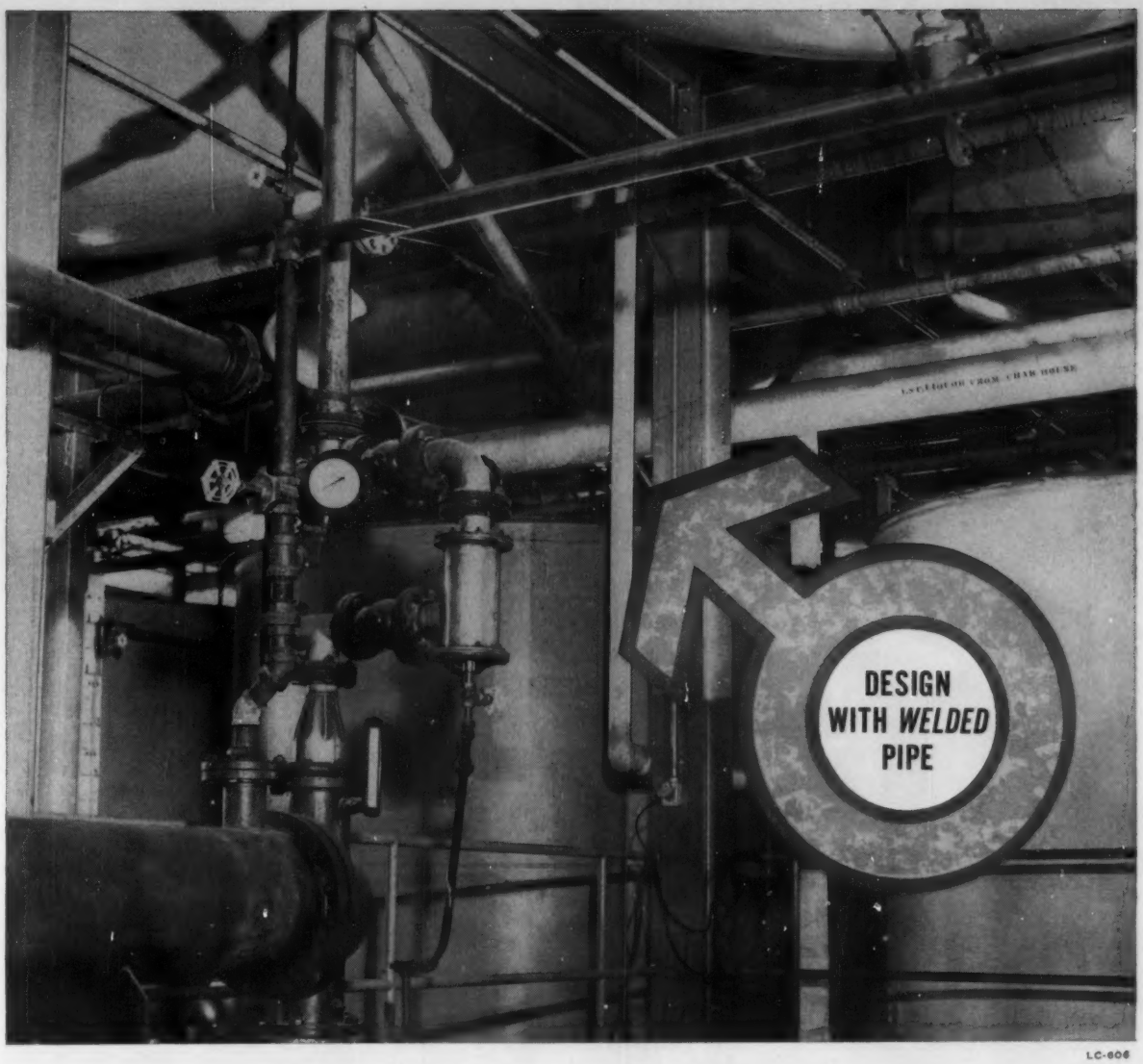
RUM can maneuver and operate at 3 mph on grades up to 60 per cent on its tracks. It is designed for a maximum depth of 20,000 ft.

To enable the tractor to surmount difficult sea-bed terrain, Hughes Aircraft Co., Culver City, Calif., has designed an "underwater-helicopter" attachment capable of lifting 8000 lb at a vertical speed of 2 fps. Three high-lift, low-speed rotor blades have remotely operated yaw, velocity, and altitude controls. To ensure that no torque is transmitted to the tractor, the blades are turned by horizontally mounted propellers driven by totally enclosed electric motors. The helicopter, says Hughes, is capable of operating in salt water for months without damage.

The mechanical arm for RUM, designed by General Mills Inc., Minneapolis, Minn., is similar to those in use in atomic laboratories around the country. It is oil-filled to simplify the pressure problem, and built of stainless steel to minimize corrosion. It can retrieve samples from the ocean floor or perform maintenance tasks on the tractor itself. A hook on the same boom as the mechanical arm has a lifting capability of 170 lb at maximum outstretch.

To monitor operations from the beach and to help in uncovering valuable scientific data from the sea bed, four specially designed television cameras will be mounted atop the tractor. Light will be provided by powerful mercury-vapor lamps.

RUM's future depends, to a large extent, on the administration's attitude toward oceanographic research. One suggested use for the vehicle is for assembly and installation of deep-sea research instrumentation. But the Interagency Committee on Oceanography claims $120,228,000 is needed for the coming fiscal-year program. Presently, the administration has requested half of this amount. The principal cause of such large expenditures, a house committee reports, is a complete lack of effective co-ordination among the government agencies handling the program.



LC-606

WELDED STAINLESS PIPING WINS

on "killer" duty in Southern Sugar Refinery

Corrosive liquors piped over long distances in this sugar refinery service—often at temperatures of from 180°F to 220°F—played havoc with non-ferrous metal piping. Down times occurred two or three times a year for pipe replacement and costs climbed accordingly . . . until welded stainless pipe entered the picture. Now, with Type 347 stainless on the job the problem is solved.

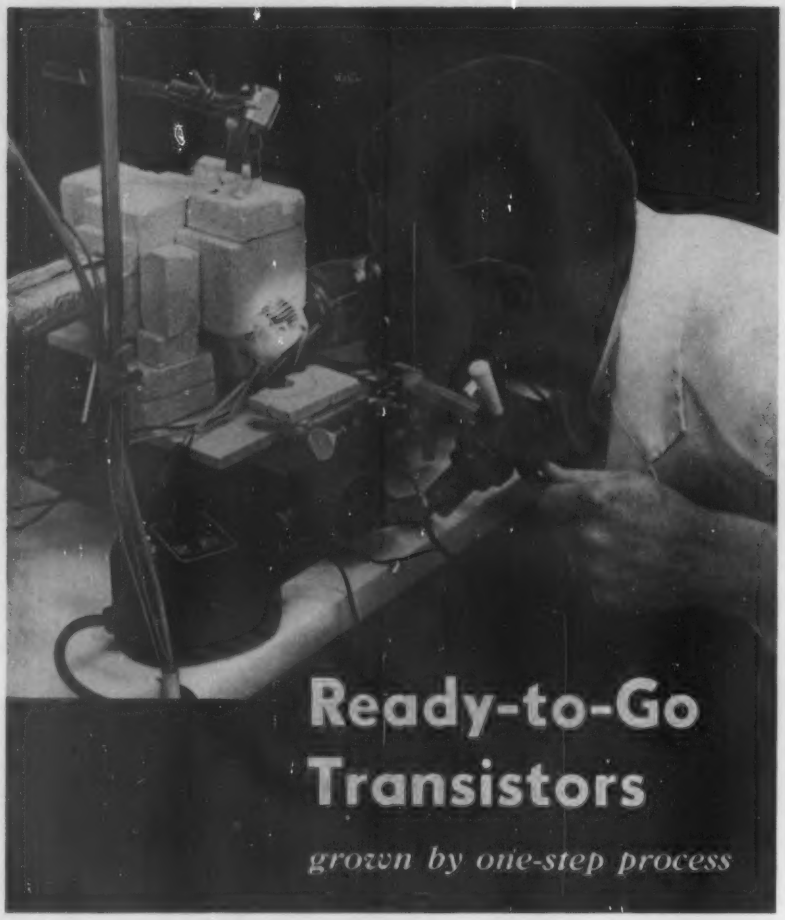
Frequent down times are eliminated, thanks to the alloy's superior corrosion resistance, and as an important bonus, freedom from product contamination is achieved. • Why not check into the profit possibilities of modern welded steel piping in your own operation? Ask for helpful Bulletin 8591—and consult a quality welded steel pipe producer in your district.

Formed Steel Tube Institute, Inc.

1603H Hanna Building, Cleveland 15, Ohio

• Armco Steel Corp. • The Babcock & Wilcox Co., Tubular Products Div. • The Carpenter Steel Co., Alloy Tube Div. • Clayton Mark & Co. • Damascus Tube Co. • Jones & Laughlin Steel Corp., Electricweld Tube Div. • National Tube Div., United States Steel Corp. • Ohio Seamless Tube Div. of Copperweld Steel Co. • Republic Steel Corp., Steel and Tubes Div. • Revere Copper and Brass Inc., Rome Manufacturing Company Div. • Sawhill Tubular Products, Inc. • Southeastern Metals Co. • The Standard Tube Co. • Superior Tube Co. • Trent Tube Co., Subs. Crucible Steel Co. of America • Union Steel Corp. • Van Huffel Tube Corp. • Wall Tube & Metal Products Co.

Circle 415 on Page 19



Iodide vapor picks up semiconductor material at the hot end of a glass tube, deposits it on a growing seed at the cold end. Layers of different materials can be added in atomic thicknesses to form diodes, transistors, tunnel diodes, and new components.

NEW YORK — Vapor growth, an atomic-bricklaying technique for fabricating transistors, tunnel diodes, etc., may outdate manual assembly of complex electronic components. Developed by scientists at International Business Machines Co., the process grows solid-state devices in a one-step operation by depositing atom-thick layers of one material on top of another. Because crystal structure of the original layer is duplicated, best advantage can be taken of each material.

By growing electronic devices directly, IBM says it can make them faster acting, more complex, and more compact. In addition, operating characteristics can be more closely controlled. Vapor growth improves the basic art of crystal growing in two ways:

• It occurs at low temperatures. Complex structures can't be formed by conventional (high temperature) techniques because new layers of semiconductor disturb those that have already cooled.

• Impurities can be added during layer formation. This gives better "dope" distribution within the crystal. In addition, it seems likely that low-temperature techniques will permit more of the desired impurities to be added (making new types of tunnel diodes and other devices possible).

The growth process takes place in an atmosphere of iodide vapors. Vapors pick up semiconductor material (from a piece of germanium or silicon) at the high-temperature end of a glass tube, then circulate into a cooler zone where the semiconductor deposits and grows on a suitable single-crystal seed. Selected impurities can be added at the cool end of the tube.

Quality of the "finished" crystal compares very well with its conventionally grown cousins: Crystalline perfection is excellent, and only one part per 100 million of iodine (from the carrier vapor) is present. Germanium crystals formed are among the most nearly perfect yet known to science.

Developed to produce functional circuit building blocks for high-speed computers, the process offers promise for automatic volume production of the more complex functional units that will soon be needed, IBM engineers claim.

Before vapor growth . . .

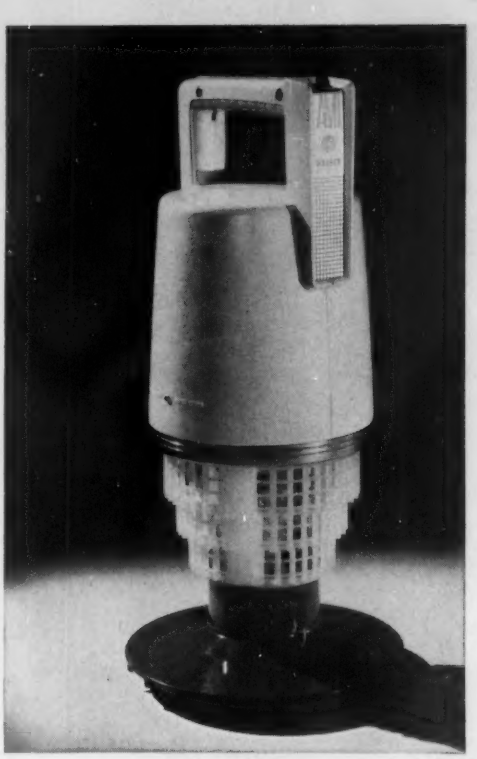
starting point for a semiconductor was a single giant crystal, produced by simultaneously drawing and chilling a molten base material. Impurities were added (to give the semiconductor its current-producing properties) by alloying or diffusing them into the molten material, or by "doping" them into the growing crystal. Next step was to slice up the semiconductor crystals into minute pieces, then carefully assemble them by hand under a microscope. Vapor growth improves these techniques in several ways, according to IBM scientists:

• Crystals are grown at low temperatures, eliminating heat stresses and permitting more complex forms.

• Impurities are added in atomic thicknesses over crystal layers, improving control of distribution and concentration.

• Transistor layers are grown rather than assembled. The technique will eliminate need for hand assembly.

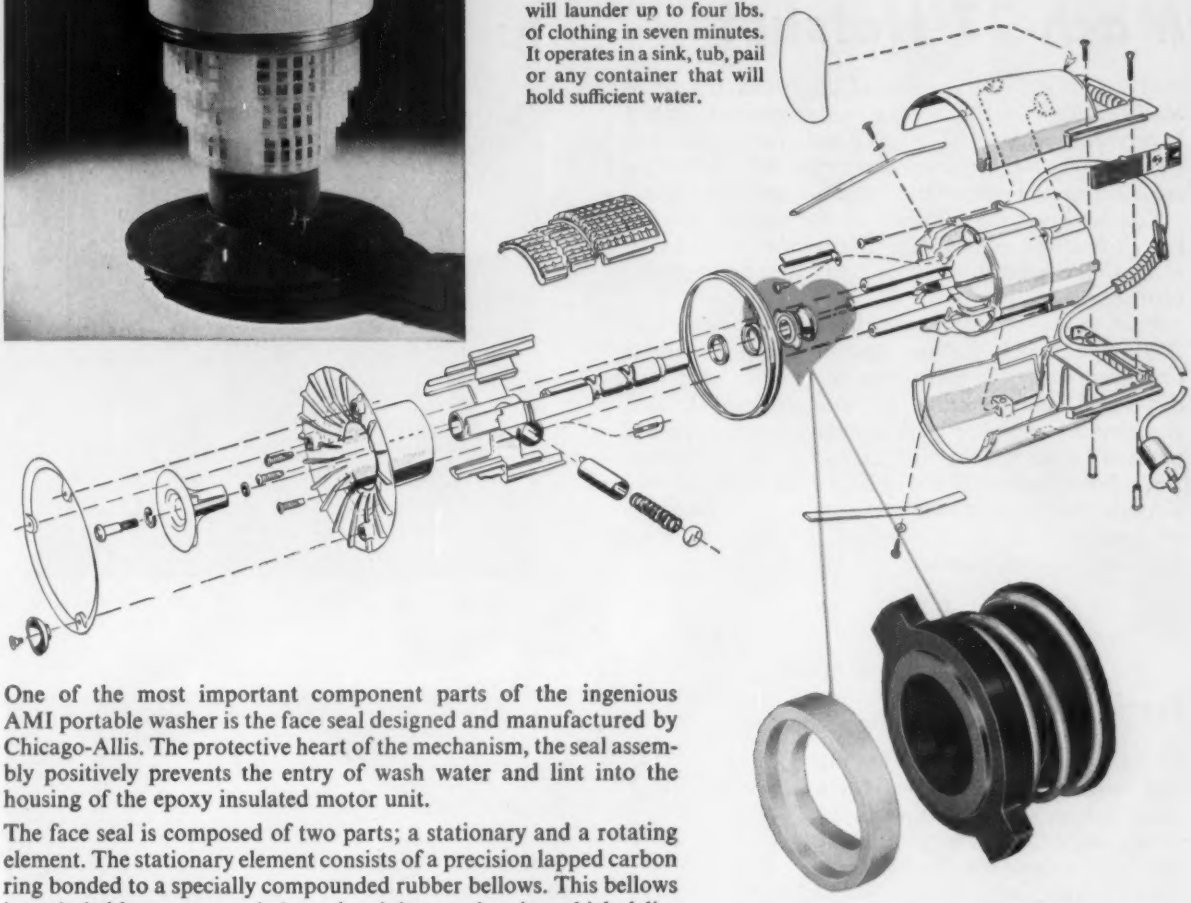
New types of tunnel diodes and entirely new electronic devices are expected to result from the vapor-growth technique, report IBM spokesmen. Vapor growth is able to produce more perfect crystals and more evenly distributed impurities; higher concentration of impurities (the key to new solid-state devices) may also become possible.



Positive Sealing Action

FOR THIS AMAZING PORTABLE AMI WASHER

Weighing less than 9½ lbs. this portable AMI washer will launder up to four lbs. of clothing in seven minutes. It operates in a sink, tub, pail or any container that will hold sufficient water.



One of the most important component parts of the ingenious AMI portable washer is the face seal designed and manufactured by Chicago-Allis. The protective heart of the mechanism, the seal assembly positively prevents the entry of wash water and lint into the housing of the epoxy insulated motor unit.

The face seal is composed of two parts; a stationary and a rotating element. The stationary element consists of a precision lapped carbon ring bonded to a specially compounded rubber bellows. This bellows is encircled by a pressure balanced stainless steel spring which delivers a constant sealing load to the carbon ring. The rotating element is a lapped ceramic mating ring which, when driven by the motor shaft, serves as an ideally inert and frictionless seat for the carbon ring and/or its stationary sealing elements.

Chicago-Allis engineers have many years of experience to offer in the design of custom molded rubber parts, shaft or face type seals, packings, gaskets, or mechanical leathers. These design skills are backed by complete laboratory and manufacturing facilities.

There's a Chicago-Allis sales engineer in every principal city area. He is available for consultation always. We will be glad to send our catalog of products and services upon your request.

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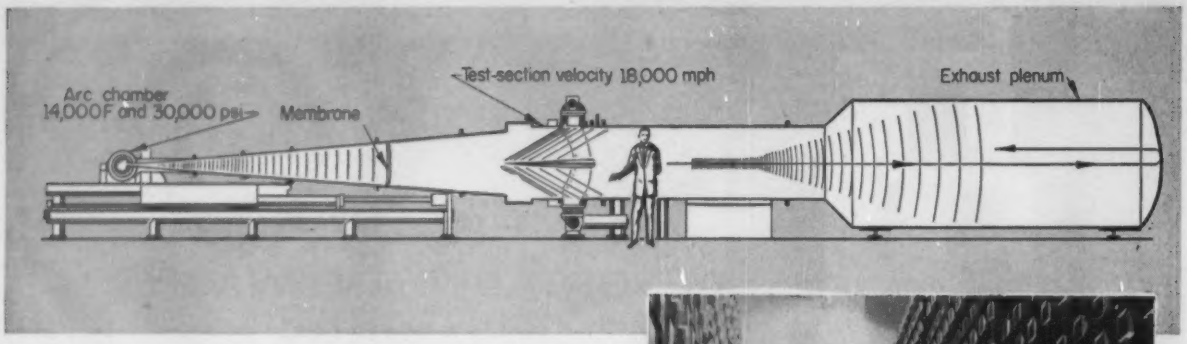
Circle 416 on Page 19



Mach-27 Hotshot

SEATTLE, WASH.—A roomful of capacitors triggers a Mach-27 blast in the world's largest privately owned hypervelocity tunnel. Up to 7 million watt-seconds (5 million hp) of electrical energy are delivered to the arc chamber in a split second by 2280 capacitors (right).

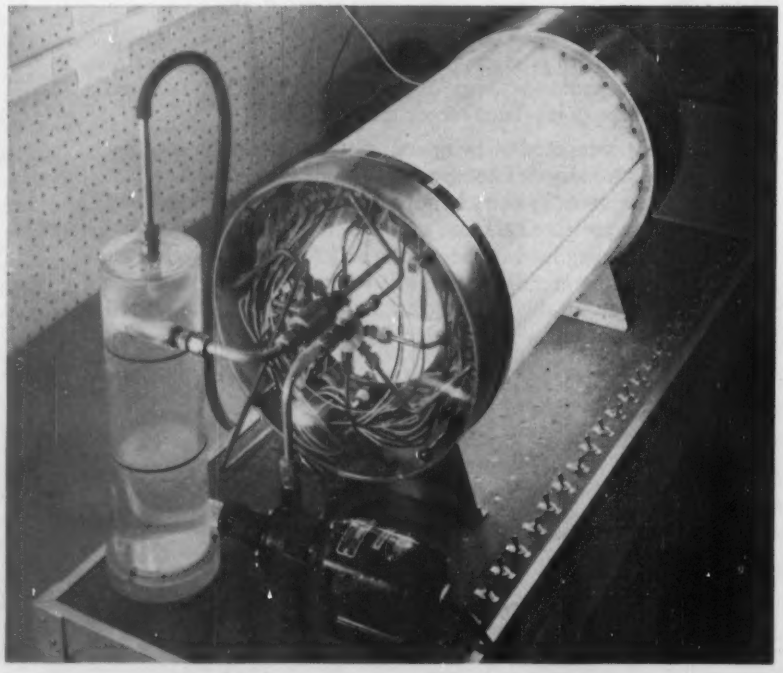
Regular operating schedule of the tunnel calls for two to four test runs a day. The builder, Boeing Airplane Co., expects to use it in Dyna-Soar and Minuteman programs.

Prior to a test run, the arc chamber is charged with 2000-psi air and the test section (downstream) is evacuated to a few millimeters of mercury. A plastic diaphragm maintains the pressure differential. Discharging the capacitor bank increases temperature and pressure in the arc chamber, rupturing the membrane. Air, released at 14,000 F and 30,000 psi, forces its way through the nozzle to the test section. Test time, approximately 1/10 sec, is limited by shock reflection from the plenum chamber.

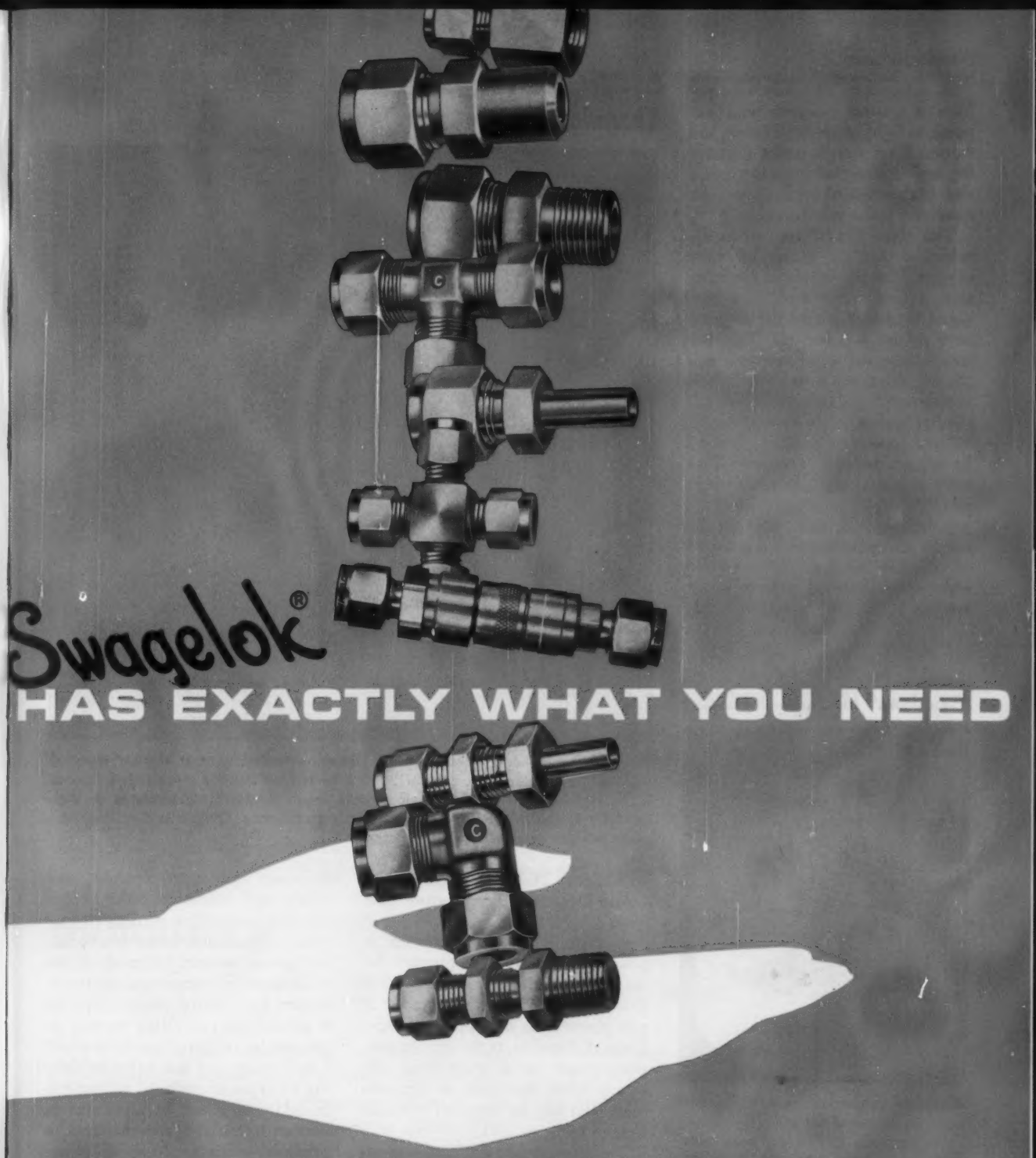
Fresh Air in Space

CLEVELAND—Breathable air for the first space men now seems likely to come from equipment that duplicates natural-life processes. A closed-cycle system developed by the Tapco Group, Thompson Ramo Wooldridge Inc., "naturally" removes carbon dioxide from air and replaces it with pure oxygen.

Certain plants and micro-organisms utilize carbon dioxide and other chemical nutrients to produce oxygen by photosynthesis, and the TRW device contains living matter of this type. In it, an algea culture (in an aqueous media) is pumped



Fluorescent light is used in the laboratory version of TRW's new oxygen regeneration system, but a lighter-weight, more practical solar collector is being developed for space applications.



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Circle 417 on Page 19

from a central reservoir and exposed to light. After irradiation, the culture flows into a cooler (removing heat transferred from the light) and is then mixed with filtered air from the space-vehicle cabin.

The algea "feeds" on carbon dioxide in this air, giving off pure oxygen. The air-oxygen-algea mixture is next transported to a gas-liquid separator where the oxygen-enriched air is taken off. The culture is returned to the reservoir and the air, saturated with water vapor, is circulated through an air-conditioning system to the cabin.

Two possible lighting systems have been designed. One uses fluorescent lamps, the other utilizes a solar collector system. Since a manned space vehicle must get the maximum performance and reliability with minimum weight and power requirements, the solar collector appears to be the more practical.

"Windows" for Sight and Sound

Complete protection from heat and shock is provided for Mercury capsule radio antennas by silica glass shields. Only an eighth of an inch thick, the shields are transparent to radio signals, but so resistant to thermal shock that they can be plunged from a high temperature into icy water without damage. Corning Glass Works, New York, N. Y., which is also making the capsule viewports, announced that it's making three of the curved, translucent antenna shields for each of the 12 capsules of project Mercury. The shields are formed by grinding glass blanks to the right thickness and sagging them under heat to the precise curvature required.

Thermionics Makes Its Move

Thermionic tube developed by RCA (shown mounted over a circular magnet) operates at temperatures around 2000 F to convert heat to electricity. Efficiency is 14 per cent. Earlier thermionic devices required source temperatures as high as 4000 F, but still didn't have as high an efficiency. Civilian and military applications are predicted by the company.

Efficiency Now Reasonable And Operating Temperature Low

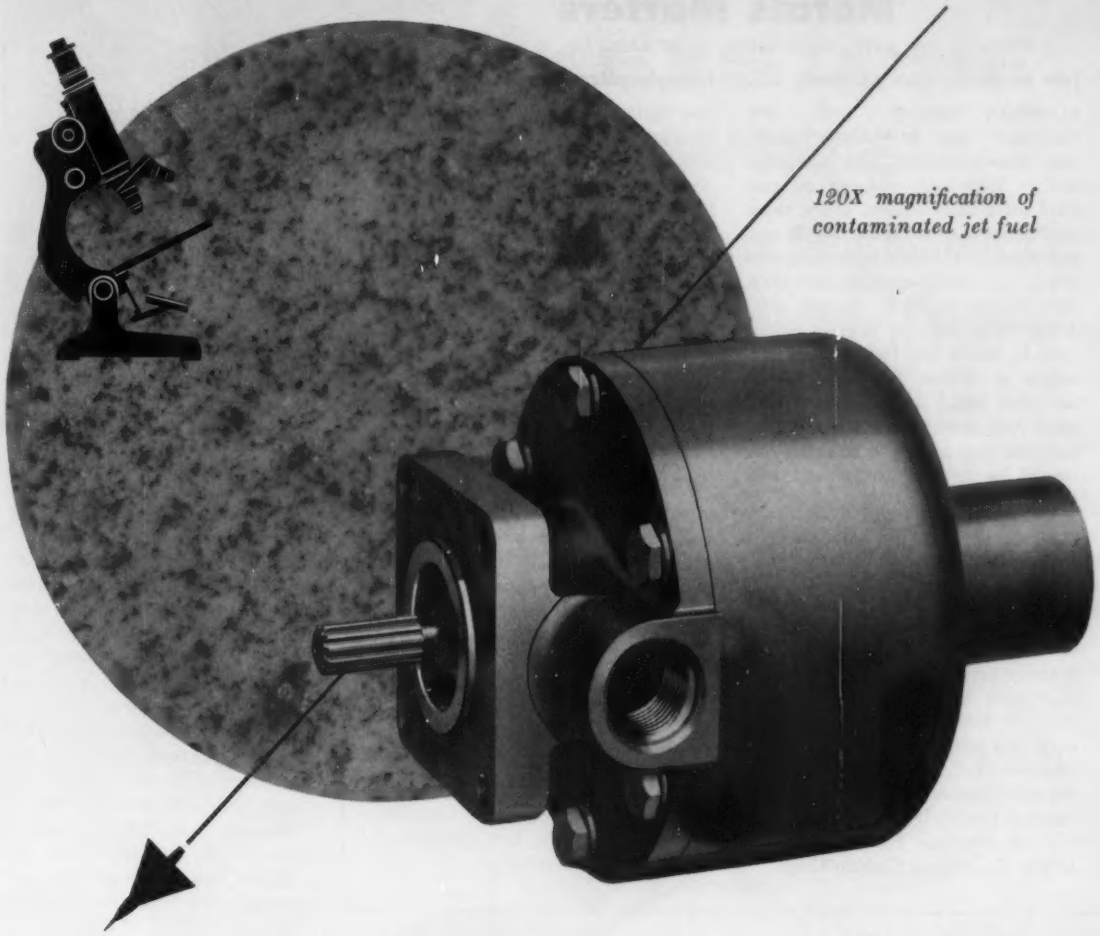
PRINCETON, N. J.—Thermionics is now a more serious contender for the jobs where direct conversion of heat to electricity is attractive. A new power tube, developed by Radio Corp. of America, is the first to generate power at a respectable efficiency while operating at temperatures that can be obtained with ordinary fuels.

The tube, called a thermionic energy converter, has operated during test from heat sources at 2000 F—a temperature that can be easily reached by burning gas-air mixtures. It has converted up to 14 per cent of the heat input into electrical energy. Until now, thermionic devices have been unable to operate at anywhere near this efficiency unless source temperatures were in the 3500-4000 F range.

Although developed especially for the task of converting solar energy to power for space vehicles, the tube's high efficiency makes it potentially competitive with small gasoline engines and other fractional-horsepower devices. Offering all the advantages of completely silent operation (no moving parts), the tube is capable of generating current at frequencies ranging from dc to about 1 million cps and is suitable for driving all types of electrical equipment. In addition, it can be fabricated in various forms and arrangements to produce whatever level of power might be required.

Improved performance of the device, says Dr. Karl G. Hernquist, the researcher credited with the development, is due to a new arrangement of internal tube elements and a different type of cathode. By allowing maximum electron flow at low temperatures, the cathode makes possible tube design for long service life and opens the door for thermionic power in the civilian world as well as in the military.

NEW VANE-TYPE FUEL PUMP



. . . . Gives longer service life when pumping contaminated jet engine fuels at high volumes and pressures

Vickers balanced-vane type jet engine fuel pumps designed to meet stringent MIL-E-5009B and MIL-E-8595 contaminant tolerance requirements are available in a size range of 500 to 50,000 PPH, develop up to 1000 psi and operate at speeds up to 6000 rpm. Pumps can be provided for speeds as high as 20,000 rpm and pressures above 1500 psi, where required. The housing configuration is adapted to specific installations.

Model shown has these performance characteristics: Pressure—to 1000 psi; flow—4000 PPH, speed—4000 RPM; temperature range—65° to 300° F, weight—5 lbs, size—4 3/32" dia., 5 5/8" long.

Designed for a service life of 1000 hours, the new Vickers vane pump was proved in more than 3400 hours of rigorous testing over the last two years (see Bulletin A-5242). Wear compensating parts and new material combinations extend service life.

Write for Bulletin A-5242 for more details.

AERO HYDRAULICS DIVISION
VICKERS INCORPORATED
DETROIT 32, MICHIGAN

division of
SPERRY RAND CORPORATION

8472

Metals Matters

Two to three times as strong . . .

as ordinary construction steel, a new super-alloy can be rolled, formed, deep drawn, welded, and machined easily. Since only one-half or one-third the normal amount of the metal need be used, an automatic weight savings results. The new steel, designated MX-2, is a cobalt-modified, low-alloy, high-strength material. It was originally developed for missile motor cases by Scaife Co., Pittsburgh, a subsidiary of Wilson Brothers. Wilson says that MX-2, in comparison with other high-strength steels, appears to have the least sensitivity to weaknesses created by notches, cracks, and heat treatment.

Corrosion resistance . . .

of titanium-0.2 per cent palladium has been tested extensively and found to be excellent. Samples of commercial titanium and the alloy were suspended in boiling 5 per cent sulfuric acid. After 85 hours, the commercial titanium was removed because of excessive corrosion, but the titanium-palladium remained under test for 170 days, showing very little corrosion. The alloy was developed by Union Carbide Metals Co., Union Carbide Corp.

Strongly piezoelectric . . .

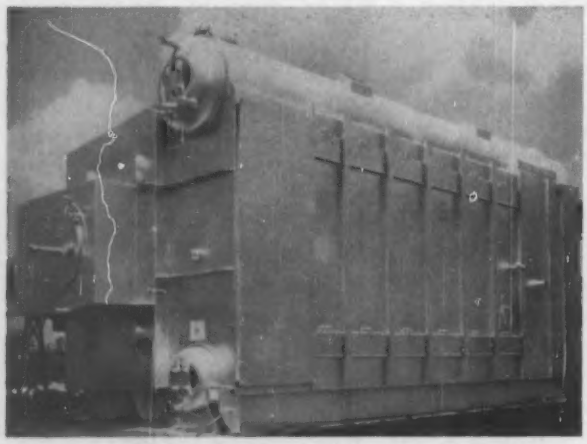
zinc oxide and cadmium sulfide may find use in highly efficient electromechanical transducers for generating ultrasonic and radio frequencies. Demonstrating the piezoelectricity of these two materials, Dr. A. R. Hutson, Bell Telephone Laboratories, showed that zinc oxide exhibits four times as much as quartz, and cadmium sulfide, twice as much. The zinc oxide was doped with lithium to neutralize excess conductivity, which has previously masked the piezoelectric effect.

Pure columbium . . .

coated with nichrome alloy, stainless steel, chromium, or modified molybdenum disilicide (LM-5) type coating can be used in the temperature range between 900 and 1500 C, according to results of a study made by S. T. Wlodek, research metallurgist in the Metals Research Laboratory of Union Carbide Metals Co., Div. of Union Carbide Corp. Uncoated columbium alloys can be produced with oxidation resistance 100 times better than pure columbium, but they sacrifice fabricability and a low ductile-brittle transition temperature.

Steel Gives Oxygen to MDs

Emergency oxygen sufficient for an hour can be stored in a 4-in. spherical container built with a new alloy. Fabrication of the 2-lb sphere requires hydrogen brazing at heats up to 2100 F, reports National Steel Corp., Detroit. Unable to find any metals capable of taking the strain of this fabrication, the company spent six years of research developing its own —a columbium-steel alloy. Breath o' Life Inc., Cleveland, designers of the lightweight tank, point out that it will replace a large, 125-lb cylindrical tank that can only be kept in hospitals or ambulances. The company hopes that every doctor's and dentist's office and automobile will eventually carry emergency oxygen.



Ready-Made CO Boiler

Uruguay will be the recipient of the world's first shop-assembled carbon monoxide boiler. The new boiler, by Babcock and Wilcox Co., will give smaller companies the chance to equal heat-balance efficiencies of the larger ones. The unit is designed for steam pressure of 600 psi at an operating temperature of 750 F. It will generate steam at a rate of 23,000 lb per hr from waste regenerator gases, or 40,000 lb per hr from oil.

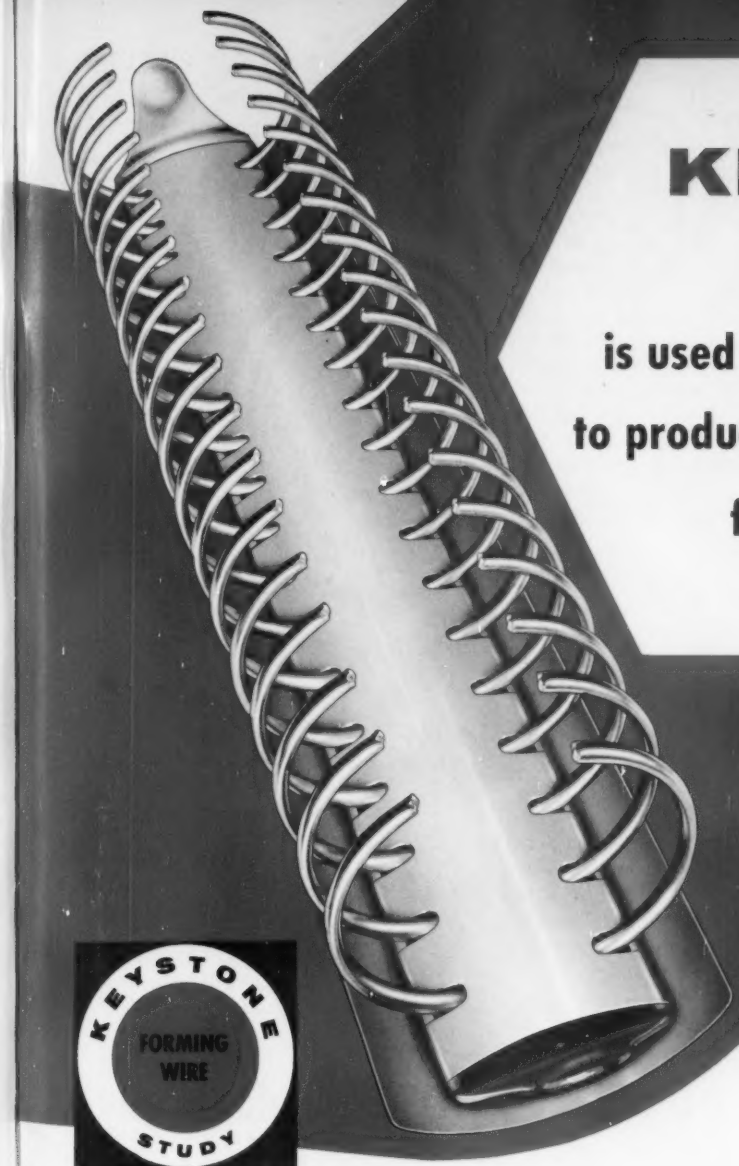
Rotational Molding Shows Its Worth

Unharmed after falling ten thousand feet into water, a marine buoy demonstrates its tremendous impact resistance. Oshkosh Plastics Products Inc., Oshkosh, Ill., is imparting the high strength to its Thermisol line of products by the use of a rotational molding method for plastisols and a new liquid cure drying technique. The company makes buoys, boat fenders, and specialty products. Fluorescent colors can be included in the product in processing.

Circle 419 on Page 19→

KEYSTONE WIRE

is used by Loose Leaf Metals Co. to produce high quality hardware for loose leaf books



Loose Leaf Metals Co. produces a wide range of quality products, including the rings shown here.

KEYSTONE FORMING WIRE STUDY

Manufacturers of loose leaf binders look to Loose Leaf Metals Co. for their hardware needs. And, in turn, Loose Leaf Metals looks to Keystone for forming wire that has all the necessary properties for quality manufacture of their rings.

To manufacture quality, precision-made rings at low cost on a mass-production basis, Keystone specially-developed copper coated annealed-in-process Forming Wire is used. Its superior quality and constant uniformity result in a perfectly aligned and nickel-plated ring.

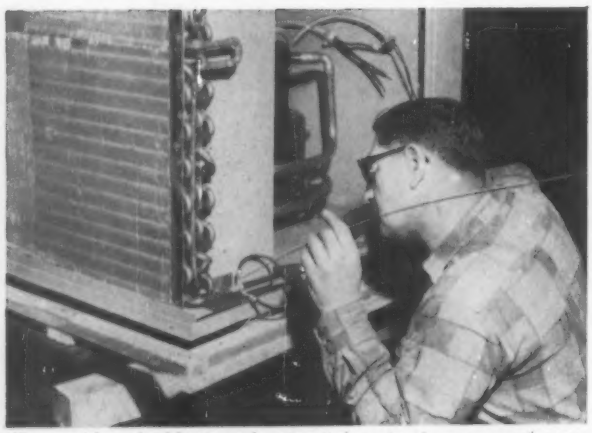
Keystone wire for Loose Leaf Metals Co.'s "Perfection" binder rings must have the correct temper so the wire can be rolled into oval shape prior to being formed into rings, then cut, swedged and deburred. In addition, the clean brite finish of Keystone Forming Wire provides a base for successful nickel plating.

The combination of Keystone experienced wire engineering, plus constantly improved marketing techniques of Loose Leaf Metals have resulted in greatly increased production of binder hardware at lower costs.

Perhaps Keystone Wire Specialists can solve your wire problems, too. Call your nearest Keystone representative, or write us for details. *Keystone Steel & Wire Company, Peoria, Illinois*

KEYSTONE
WIRE FOR INDUSTRY

HOW TO MAKE 4,999 JOINTS WITHOUT FAIL



Here, with a double tipped oxyacetylene torch, operator brazes condenser coil joints. This condenser-compressor assembly contains 30 hook-up joints, not counting return bends.

The unit evaporator, located inside the house, contains 36 hand-brazed SIL-FOS 5 joints.

International Heater Does it With HANDY & HARMAN SIL-FOS 5

Production statistics of this manufacturer of heating and air-conditioning equipment show that perhaps one in five thousand hand-brazed joints may need touching up. This is a micrometer measurement away from absolute perfection.

One of the Utica, New York, company's products is a home air conditioner that utilizes the existing duct work of the structure's hot-air furnace. Its novelty lies in the fact that the unit's compressor and condenser are located outside the house for noise-free coolness inside the home.

The unit's evaporator is installed on top of the furnace for simple tie-in to the plant's ducting for hot-weather operation.

Shown here in production is International's Model 5-5B of 5 ton capacity.

This "joint in quantity" record is being duplicated by SIL-FOS 5 silver alloy brazing in the manufacture of heating, air-conditioning and refrigeration equipment everywhere. Its strength, air- and leak-tightness and ease of application are some of the reasons that make Handy & Harman SIL-FOS 5 brazing one of the *surest* metal joiners in existence. We'd like you to know more about SIL-FOS 5 and the job it can do for you in joining copper and copper alloys in any shape, size and complexity. Our Bulletin 20 deals with this in a complete and informative manner. A request to Handy & Harman, 82 Fulton Street, New York City 38 will bring you your copy.

Your No. 1 Source of Supply and Authority on Brazing Alloys

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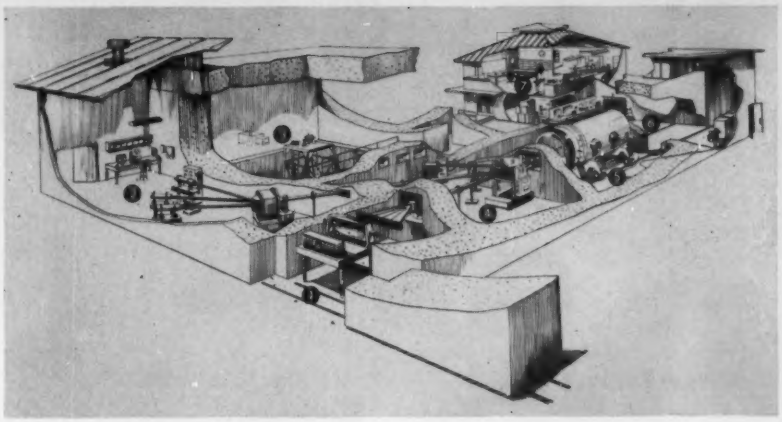
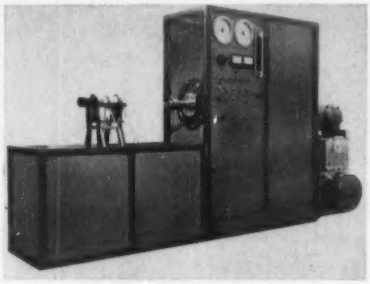


Radiation-Damage Lab

Research on the effects of radiation on electronic components and systems should get a big boost from a new lab now going up. The facility, being built by Convair Div., General Dynamics Corp., will contain an electron/ion accelerator able to produce a beam ten times more powerful than that from any similar machine. Designed by Radiation Dynamics Inc., the accelerator will operate in the 0.1-3 Mev (million electron-volt) range with currents up to 10 ma. Neutron output will be as high as 6×10^{13} per sec—comparable to that produced from 500,000 curies of cobalt 60. Facilities and equipment included in the laboratory will include: 1. Irradiation cell for studies on damage to electronic components. 2. Nuclear physics experimentation area. 3. Neutron test area. 4. Magnet to "steer" beams to appropriate test cells. 5. The accelerator. 6. Accessory room for operation and maintenance of the accelerator. 7. Control room.



MHD Researchers Get a New Tool

Flow generators designed to produce a continuous flow of ionized gas for magnetohydrodynamic experiments can now be purchased as off-the-shelf items. First company to offer a packaged flow facility, MHD Research Inc., Newport Beach, Calif., pushes flow into the 3 mile per sec range with a gas-stabilized electric arc that's capable of producing stagnation temperatures of over 10,000 K. Average conductivity of the gas stream is 1 mho per cm. Acceleration of plasma streams, power generation by MHD, and kinetic-transport properties of ionized gases are only a few of the areas that can be explored with the laboratory-bench size tool, company spokesmen report.

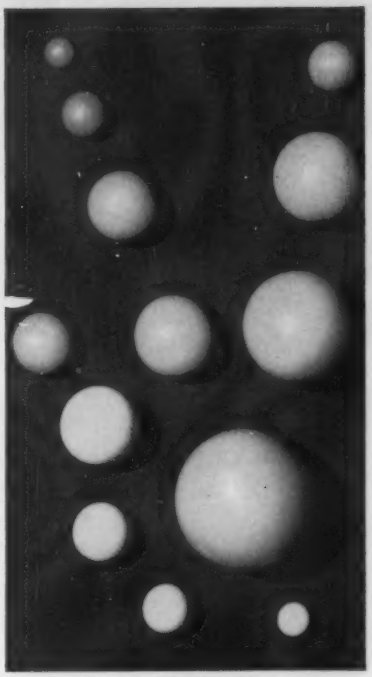
Future P. E. Must Be Ph.D

ANN ARBOR, MICH.—To assure future technological development, professional schools of engineering are needed. Speaking at the University of Michigan recently, Professor J. E. McKee of the California Institute of Technology said that whereas theology, law, and medicine have developed largely through professional schools, basic sciences have remained within the fold of graduate academic programs leading to the Ph.D. Engineering has now reached the stage of educational development where it must branch out on its own.

To augment this proposal as quickly as possible, the Engineers Council for Professional Development should establish a committee to study the advisability of such schools, said Professor McKee. Only through the engineering societies (which ECPD serves) will these professional schools ever be established. He said that it is unlikely that engineering faculties will take the initiative.

If ECPD takes a strong position, he continued, many universities will quickly follow suit.

CLEAN AND CLEAR BALLS



OF NYLON AND TEFLON

Because of improved grinding and finishing methods, ITI Nylon and Teflon balls are FREE OF EMBEDDED SURFACE GRIT. Their clean, clear finish assures THE BEST in performance for your products.

These balls are available in all sizes — standard (carried in stock) and special. Samples free on letterhead request.

Write **for prices and specifications.**

ITI
INDUSTRIAL TECTONICS, Inc.
MANUFACTURERS OF PRECISION BALLS AND BEARINGS
3663 Jackson Road, Ann Arbor, Michigan

Circle 420 on Page 19

NEW

Modernair

"SERIES R"

Patents Pending

for Air
or Hydraulic
Service to 200 psi

ECONOMAIR CYLINDERS

DESIGNED EXCLUSIVELY FOR THE MAN WHO WANTS COMPACTNESS, RELIABILITY AND ECONOMY!

Introduced by Modernair in 1948, these ultra-compact cylinders have been performance-proved on thousands of jobs all over the free world.

Today's new Series R ECONOMAIR cylinder is even better. In addition to such original advantages as compactness and interchangeable mountings, the new Series R offers:

- Chrome plated stress-proof steel piston rods with wrench flats.
- Built-in rod wipers.
- Wider-sectioned aluminum piston for improved bearing stability.
- Exclusive Adjusto-Stroke Design. (Pat. Pend.)
- 1⅛ bore has stainless steel rod.

Series R ECONOMAIR cylinders are available now in 1⅛, 1½, 2, 3 and 4-inch bore sizes, with or without cushions. They offer today's best buy in quality cylinders at truly competitive prices—why pay more and get less?

See your phone book yellow pages for your nearest dealer or write us now for literature and prices. Please address Dept. 63

Modernair CORPORATION

400 Prods Street • San Leandro, California
5007 Brookpark Road • Cleveland 34, Ohio

Circle 421 on Page 19

Engineers Honored

• The National Society of Professional Engineers, in its annual election last month, chose as its new president the general manager and vice president of Hughes Tool Co., Noah E. Hull.

Mr. Hull of Houston, Tex., served as NSPE vice president for the southwestern region prior to his election. A registered professional engineer in three states, Michigan, New York, and Texas, he is former chairman of the Professional Engineers Conference Board for Industry (1955-58).

Mr. Hull received his degree in civil engineering from Purdue University in 1917. He held executive engineering positions with General Motors Corp., Firth Carpet Co., and National Gypsum Co. before joining Hughes.

• The American Society of Heating, Refrigerating and Air-Conditioning Engineers recently honored one of its members. ASHRAE past-president and fellow, Peter Ben Gordon has been awarded the society's highest honor, the F. Paul Anderson medal for contributions to society and the profession. Mr. Gordon is a representative on the Engineers Joint Council. He is a vice president of Wolff and Munier Inc. and an alumnus of Rutgers University.

Meetings and Shows

Aug. 23-26—
Western Electronic Show and Convention to be held in the Memorial Sports Arena, Los Angeles. Sponsors are the Western Electronic Manufacturers Association and the Institute of Radio Engineers. Additional information is available from Wescon, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Sept. 6-16—
Production Engineering Show to be held at the Navy Pier, Chicago. Further information is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 6-16—
National Machine Tool Builders Association. Machine Tool Exposition to be held at the International Amphitheatre, Chicago. Additional information is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 7-9—
Joint Automatic Control Conference to be held at Massachusetts Institute of Technology, Cambridge, Mass. Sponsors are Instrument Society of America, American Society of Mechanical Engineers, American Institute of Electrical Engineers, Institute of Radio Engineers, and American Institute of Chemical Engineers. Additional information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

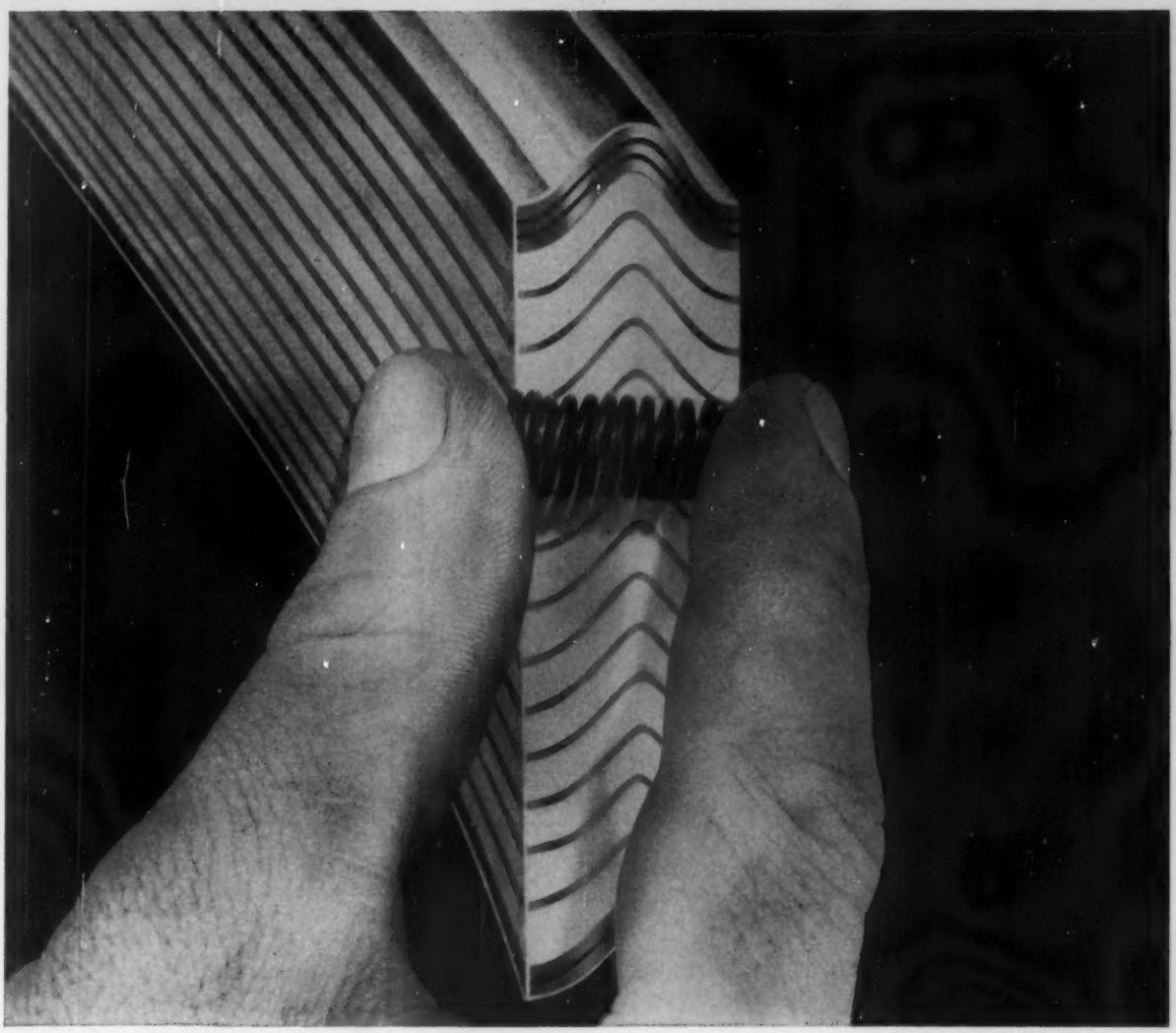
Sept. 12-15—
Society of Automotive Engineers Inc. National Farm, Construction, and Industrial Machinery Meeting, including production forum and engineering display, to be held at the Milwaukee Auditorium, Milwaukee. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Sept. 15-16—
American Society of Mechanical Engineers. Engineering Management Conference to be held at the Morrison Hotel, Chicago. Additional information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 18-21—
American Society of Mechanical Engineers. Petroleum - Mechanical Engineering Conference to be held at the Jung Hotel, New Orleans, La. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

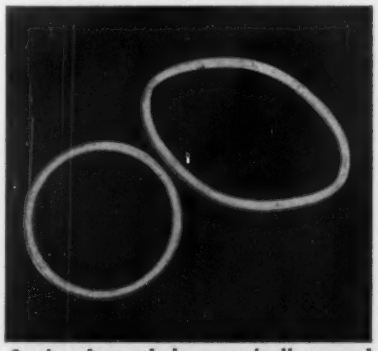
Sept. 19-20—
Steel Founders' Society of America. Fall Meeting to be held at the Homestead, Hot Springs, Va. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Sept. 21-23—
American Society of Mechanical



"Spring Action" gives you a leakproof seal with J-M SPIROTALLIC® GASKETS

Johns-Manville makes a specialty of building a lively "spring action" into Spirotallic Gaskets. Because of their superior resiliency, Spirotallic Gaskets can compensate for varying stresses and temperature changes ... follow minor flange separation ... and absorb vibration. Even under these difficult circumstances, they keep a tight, durable seal.



Oval and round shapes spirally wound

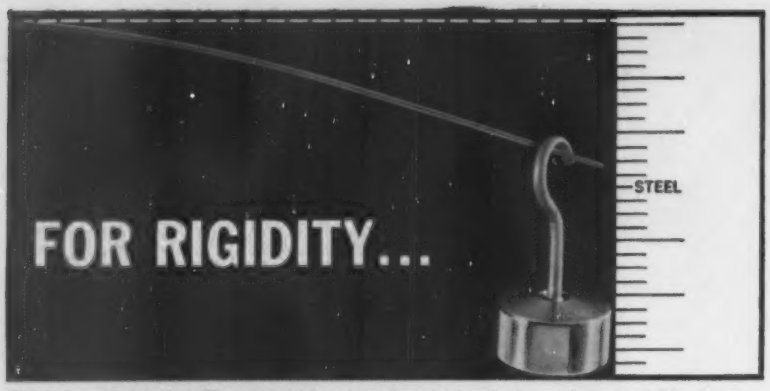
This quick adaptability has given Spirotallic Gaskets a tremendous popularity in the field. Their springiness is due to the special methods and control J-M uses in their manufacture. Spring-like metal strips, formed into a special vee shape, are alternately spiral-wound with an asbestos filler. The filler does the sealing . . . and the vee shape provides the "spring."

Another reason for the widespread acceptance of Spirotallic Gaskets is the fact that when the gasket has been compressed the proper amount, it reaches optimum performance for the bolting. Many different metals and fillers can be used. Each metal is color-coded to aid maintenance personnel in quick identification of the type of metal used.

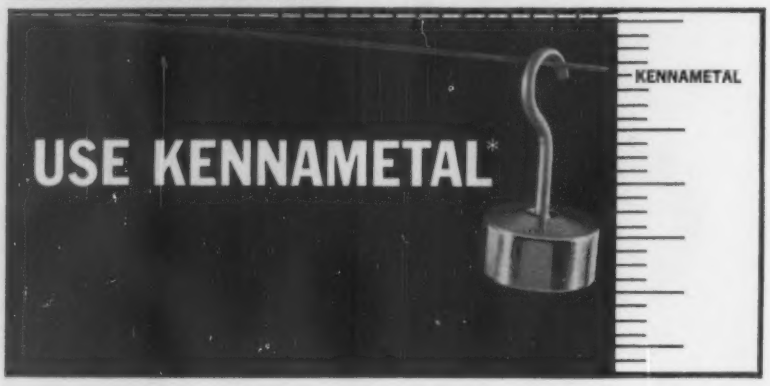
J-M produces a wide variety of sizes and shapes for standard flanges. And for special flanges, J-M will design and produce a gasket with the precise characteristics you require. For complete information, ask for J-M catalog PK-35A. Write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

Circle 422 on Page 19



Equally weighted, a Kennametal rod and a steel rod of equal size quickly demonstrate the greater rigidity of Kennametal. The Kennametal rod registers only ⅓ as much deflection as the steel rod.



As a design material . . . Kennametal has many searched-for physical properties. Rigidity is one of them.

Three times as rigid as steel . . . Kennametal has a YME up to 94.3 million psi as compared to 30 million for steel. This property has already solved many problems of deformation, deflection, bending, vibration, and chatter. There are two ways it might solve a problem for *you*. First, by permitting increased loading, as Kennametal deflects only ⅓ as much as steel under the same load. Or, if deflection and loading are acceptable, a part made of Kennametal will require less mass than other materials. Thus, machine elements may be miniaturized where compactness is essential.

Rigidity is but one of the many exceptional properties of Kennametal. When you need great resistance to heat, corrosion, abrasion, erosion, and compression . . . chances are Kennametal may be the answer.

To help solve an immediate problem, or a future need . . . we'd like to send you Booklet B-111B, "Properties of Kennametal," and our new Booklet B-666,"Proven Uses of Kennametal and Kentanium."* Write Dept. MD, KENNAMETAL INC., Latrobe, Pennsylvania.

*Kennametal is the registered trademark of a series of hard carbide alloys of tungsten, tungsten-titanium, and tantalum. Kentanium is the registered trademark for one of the series that has special advantages for applications requiring a lighter weight material, or maximum resistance to temperature extremes.

33508

INDUSTRY AND
KENNAMETAL
...Partners in Progress

Engineers - American Institute of Electrical Engineers Power Conference to be held at the Bellevue-Stratford Hotel, Philadelphia. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 26-29—

American Welding Society. Fall Meeting to be held at the Penn-Sheraton Hotel, Pittsburgh. Additional information is available from AWS headquarters, 33 W. 39th St., New York 18, N. Y.

Sept. 26-30—

Instrument Society of America. Instrument-Automation Conference and Exhibit and 15th Annual Meeting to be held in the Coliseum, New York. Additional information can be obtained from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 27-30—

American Rocket Society Inc. Space Power Systems Conference to be held at the Miramar Hotel, Santa Monica, Calif. Additional information can be obtained from society headquarters, 500 Fifth Ave., New York 36, N. Y.

Sept. 27-30—

Association of Iron and Steel Engineers. Exposition and Convention to be held at the Auditorium, Cleveland. Further information is available from AISE headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Oct. 9-12—

American Society of Mechanical Engineers. Rubber and Plastics Conference to be held at the Lawrence Hotel, Erie, Pa. Further information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Oct. 9-14—

American Institute of Electrical Engineers. Fall General Meeting to be held at the Morrison Hotel, Chicago. Additional information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Oct. 10-11—

Sixth Conference on Mechanisms to be held at Purdue University,

Lafayette, Ind. Conference is sponsored by Purdue and MACHINE DESIGN. Further information is available from Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Oct. 14-15—

American Society for Quality Control. 15th Midwest Conference to be held at the Broadview Hotel, Wichita, Kans. Further information can be obtained from the program and publicity vice-chairman, Howard K. Mitchell, 602 S. Brookside, Wichita 18, Kans.

Short Courses and Symposia

Aug. 15-19; 22-26, 29-Sept. 2—

Photoelasticity and Strain Gages —three one-week courses on experimental stress analysis for missiles and space craft to be held at UCLA. Included will be theory, as well as discussions and demonstrations of latest techniques, especially with respect to applications at high and low temperatures. The first week's course, on industrial photoelasticity, consists of lectures and laboratory work; the second week is a lecture course on strain gages; and the third week is a laboratory course on strain gages. Further data is available from Engineering Extension, Engineering Bldg. Unit II, Room 6266, University of California, Los Angeles 24, Calif.

Aug. 22-26—

Thermonuclear Plasma Physics Symposium, to be held in Gatlinburg, Tenn., will deal with elementary aspects of achieving controllable release of energy in significant amounts from thermonuclear fusion reactions. Sponsors are Oak Ridge National Laboratory (operated by Union Carbide Corp.) and the Oak Ridge Institute of Nuclear Studies, in co-operation with the U. S. Atomic Energy Commission. Further information can be obtained from the laboratory, P. O. Box X, Oak Ridge, Tenn.

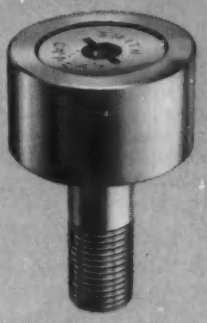
Sept. 12-16—

Course on Technical Report

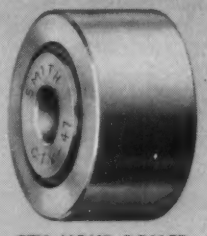
SMITH

CAM FOLLOWERS AND YOKE ROLLERS

HCS CAM FOLLOWER



CTA CAM FOLLOWER



CTY YOKE ROLLER

Precision Made For Precise Performance

Each component of Smith Cam Followers and Yoke Rollers is carefully engineered, machined and finished to the most exacting standards and dimensions. As a result, each Standard Smith Cam Followers and Yoke Roller is identical to all others of the same series and size.

Such uniformity of product results in equal uniformity of performance.

Standard Smith "CTA" (interchangeable) or "HCS" (High Capacity Stud) Cam Followers and "CTY" Yoke Rollers, assure you of outstanding performance with long, trouble-free life.

Special Smith Cam Followers and Yoke Rollers to suit special applications are supplied promptly.

Better distributors throughout the nation stock and sell Smith Cam Followers and Yoke Rollers.

Write for your new, quick reference data sheets.

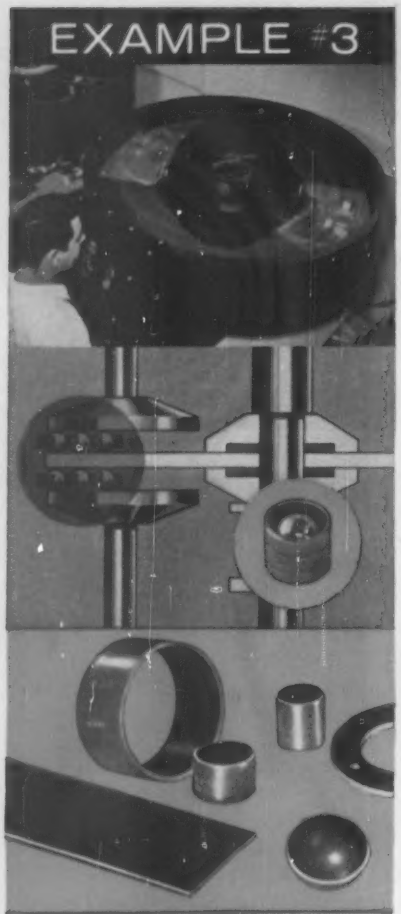
SMITH BEARING DIVISION

Accurate Bushing Company

441 North Avenue, Garwood, New Jersey

Manufacturers of: Needle Bearings, Cam Followers, Yoke Rollers, Jet Engine After Burner Rollers and Bearing Assemblies, N. A. S. Standard and Special Bearings, High Temperature and Severe Wear Precision Parts.

Circle 424 on Page 19



DU bushings (bottom) partially surround each steel ball in the new "Rouverol" ball-galaxy principle variable speed drive (center), capable of operating up to 8000 rpm. This permits dramatic advance in centrifuge equipment (top) for more accurate missile and aircraft component operational G-force testing. Design illustrates use of DU bushings in lubricated ball bearing where dry operational capability pays off in hard-to-lubricate areas.

DU* DRY BEARINGS

Solve Another Problem

"Our 909 Variable-Speed Transmission is a high-torque, ball-disc friction drive† which utilizes two clusters of steel balls for the transfer elements instead of the more conventional single-ball configuration. Many bearing materials were tested before a satisfactory cluster cage assembly was evolved. The successful design incorporated DU bushings which are partially swaged around each ball for increased bearing area. In addition to an extremely low coefficient of friction, the bushings transfer heat away from critical areas much more efficiently than other materials tested. Problems concerning wear, and tolerance of foreign particles have virtually disappeared."

R. E. Brown
Vice President—Engineering
GENISCO, INC.

DU metal is an ideal bearing material for many applications. It withstands much higher velocities, runs much cooler at lower speeds than other unlubricated bearings . . . has a compressive strength of 51,000 p.s.i. DU metal is applied without the need for temperature-limiting adhesives . . . will withstand from −328°F to +536°F.

GARLOCK

Apply DU dry bearings to appliances, automobiles, aircraft, farm and industrial machinery, office equipment. Standard bushings and thrust washers available for ¼" to 2" shafts; strip available for special fabrication. Write for engineering catalog DU-458. Special Products Dept., Garlock Inc., P.O. Box 612, Camden 1, New Jersey.

*Trademark, Glacier Metal Company Ltd.
†Manufactured under license agreement from W.S. Rouverol, University of California at Berkely

Writing for Engineers and Scientists to be held at the University of California, Los Angeles. Additional information is available from Engineering Extension, Room 6266, Engineering Bldg., Unit II, University of California, Los Angeles 24, Calif.

Sept. 14-15—

Joint Military-Industrial Electronic Test Equipment Symposium to be held at Armour Research Foundation under the sponsorship of the Office of the Director of Defense Research and Engineering and the Department of the Army Signal Corps. New concepts in measurement, latest instrumentation design techniques, and advanced data processing methods will be covered. Additional information can be obtained from Robert Brausch, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

Sept. 19-30—

Technical Report Writing for Engineers and Scientists Seminar to be held at Pennsylvania State University. Lecture, discussion, and workshop sessions will cover all phases of technical report preparation. Further information is available from Conference Center, The Pennsylvania State University, University Park, Pa.

Oct. 4-7—

Eighth Annual Human Engineering Institute to be conducted by Dunlap & Associates, Stamford, Conn. Program will include three days of technical sessions, a half-day on management and contractual aspects of human engineering efforts, and opportunity for private conferences. Further information can be obtained from Dunlap & Associates, 429 Atlantic St., Stamford, Conn.

Oct. 14-15—

Revolution in High-Speed Processing Symposium to be held by the Society of Photographic Scientists & Engineers in Washington, D. C. Short access time, compact, simplified photographic processing equipment will be discussed. Further information can be obtained from SPSE, Box 1609, Main Post Office, Washington, D. C.

Some Ideas

for your file of practical information on drafting and reproduction... from

KEUFFEL & ESSER CO.

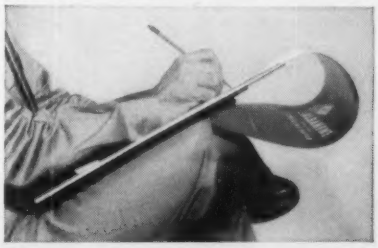
Papers, in their special way, are as different as people . . . and choosing the best paper for a specific job can be as difficult as choosing the best *person* for the job. Here at K&E, we try to do the work for you, by painstakingly determining precisely the characteristics required, then refining them to the point of excellence. Here are some good examples:

A New Type Of Typing Paper

Translucent typewriter papers are very popular of late for typed originals from which numerous copies must be made. The savings are considerable when you use translucent originals through diazo reproduction–savings up to 80% in many cases. But most translucent papers used today stand erasure very poorly. Recognizing the inevitability of human error, K&E has perfected a better translucent typewriter paper called TYPEMASTER® (193)–the perfect answer for those whose typing is less than perfect. TYPEMASTER's completely new, *engineered* surface affords outstanding erasability. A thin, unusually tough coating, it readily catches and holds the typewritten image, yet resists penetration of the ink into the paper fibers . . . and therein lies the secret of good erasability. A number of skeptics who tested the new TYPEMASTER sheets have now discarded all others. Skeptical or not – may we suggest you try it.

Tracing Pads "To Travel"

Brilliant ideas often occur at random moments. For that reason, engineers on the move usually keep a tracing pad handy. But pads with soft, chipboard backing are of little use without a desk under them. That's why all K&E tracing pads are backed with sturdy bookbinder's board – the same tough board found in any high-



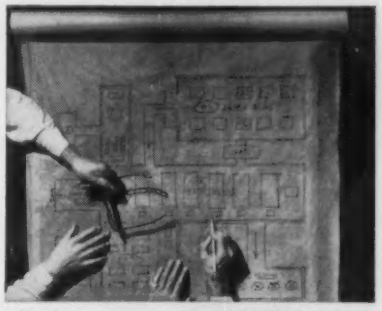
priced, permanently-bound library volume. Wherever you are you're assured desk-firm support with a K&E pad. Another plus – the sheets are bound in by a gummed edge for neat and easy removal. Available in a wide variety of grid patterns and sizes, with plain or imprinted sheets (standard headings), K&E book-bound, gummed-edge tracing pads are perfect workmates for the "portable" professional.

The Most Pampered Natural Paper In America

For the greatest transparency, the overwhelming choice is K&E ALBANENE® prepared tracing paper. But for ability to stand a lot of abuse on the drawing board and in subsequent processing and handling –many companies prefer to sacrifice some transparency and use a *natural* tracing paper. Here we recommend a truly remarkable K&E product–BANKNOTE™ (174L). This thin, flexible, 100% rag tracing paper will weather a double share of abuse. You can actually crumple a sheet of K&E BANKNOTE up into a tight ball . . . then smooth it out to find it almost as good as new for reproduction purposes! The paper makers who produce BANKNOTE for K&E proudly refer to it as America's most pampered tracing paper. No other paper we know receives the same care and attention . . . from initial inspection of the textile bales, through every step of processing, to final shipment. With K&E BANKNOTE, papermaking skills come into play as with no other paper made on this side of the Atlantic – from use of a paper machine that runs a "top jacket" (one of the few still employed), through the artful "wet packing" process, to careful air-drying, super calendering, and rewinding. The result is a sheet of unsurpassed mellowness, yet with unusual stamina and workability.

Now You Can "Talk" In Triplicate

Although low-priced canary tissue enjoys wide usage as a so-called "talking paper", we've heard many complaints about its inability to reproduce well in standard copying machines. With this in mind, we present K&E's newest LIGHTWEIGHT SKETCHING TISSUE (185) – designed specifically as a *reproducible* "talking paper." This tissue is ideal for preliminary sketching when you want sharp reproductions from a standard diazo, blueprint or office copying machines. It's a pure bleached sulphate with just enough yellow tint added to afford good contrast for pen-



cil, charcoal or crayon. You'll find K&E LIGHTWEIGHT SKETCHING TISSUE well worth any small price difference.

You can test this quartet of fine papers at your local K&E dealer's . . . or use the coupon below to get samples for private perusal. Do it *today* . . . there's a world of better work at stake.

KEUFFEL & ESSER CO., Dept. MD-8, Hoboken, N. J.

Please send me samples and further information on the following:

- ☐ K&E TYPEMASTER Translucent Typewriter Paper
- ☐ K&E BANKNOTE Tracing Paper
- ☐ K&E LIGHTWEIGHT SKETCHING TISSUE

Name & Title_____

Company & Address_____

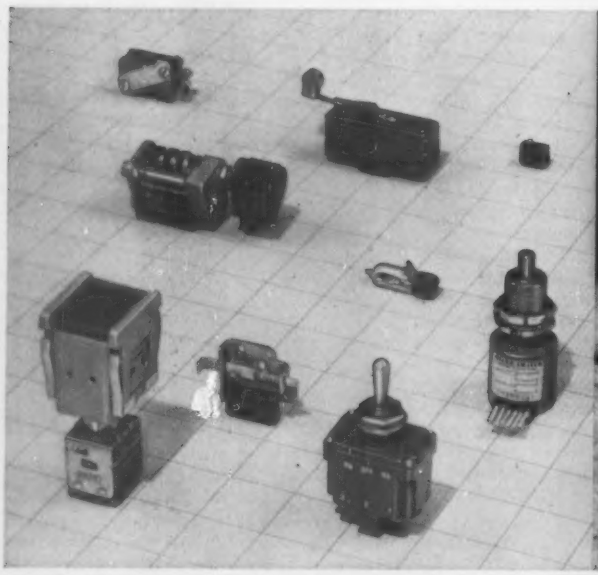
1539R

Circle 426 on Page 19

Don't compromise on switch reliability because . . .

Every touch of a Switch is a test of your equipment!

The design of switches is a specialty, one place where you can save valuable engineering time and insure that circuits will be made. But don't stake your reputation on less than the finest. MICRO SWITCH precision and reliability will safeguard your performance standards.



MICRO SWITCH offers the most complete selection of switch catalogs available on Sub-subminiature, Mercury, Push-Button, Rotary Selector, Toggle, Door Interlock and Sealed Aircraft Switches. Write for file material now.

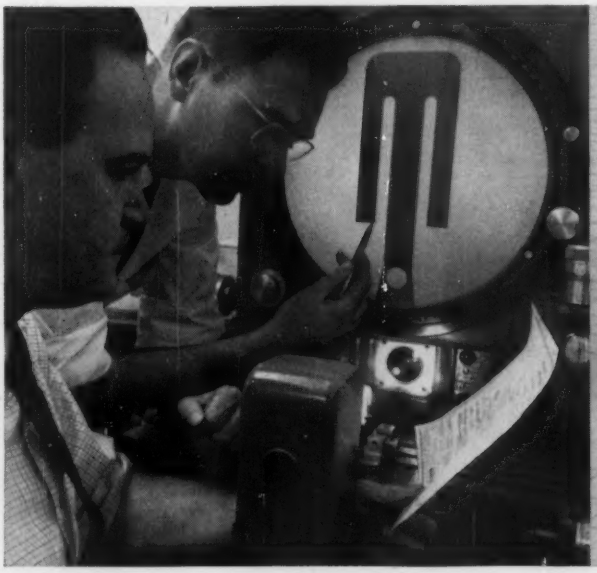
Sensitive way to crush a switch. This machine records load stress and strain from gram ranges up to five tons. Here MICRO SWITCH engineers test compression, tensile properties of materials and characteristics of switches.

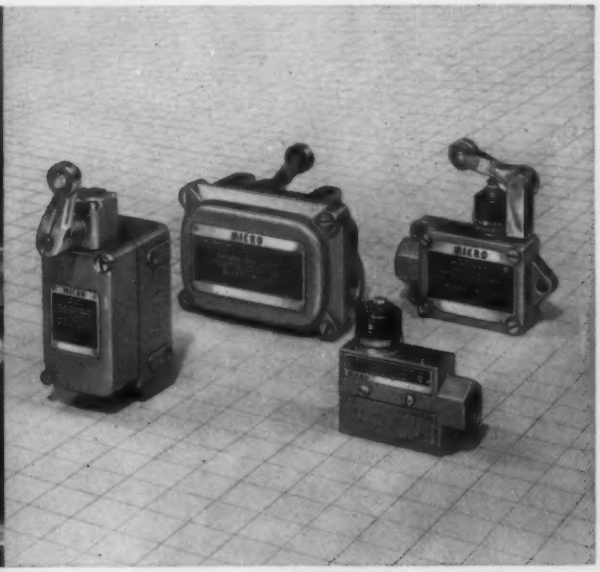
75 YEAR — HONEYWELL PIONEERING THE FUTURE

New ideas in the application of switches may automatically create new competitive advantages for your product. Many manufacturers are entrusting switches with more and more critical and varied assignments. And the same profitable opportunities are open to you. Some typical examples are the control of heat cycle and water flow of an automatic coffee maker, the ultra-sensitive responsibility of detecting the thickness of paper money, and the automatic cycling on a precision grinder at the rate of 57,000 operations per day.

But, the kinds of precision and reliability that safeguard your performance standards cannot be taken for granted in just any brand of switch. At MICRO SWITCH, the largest testing laboratory of its kind pretests switches for thousands and sometimes millions of operations, simulating on-the-job conditions of temperature, humidity, sand blasting, extreme pressure or shock and vibration.

MICRO SWITCH pioneered the design of small precision snap-action switches. Today, new applications have resulted in the design of over 12,000 different switches that make up the MICRO SWITCH line. There are sure to be some ready-made answers for *your* switch problems. For special help, see the Yellow Pages for the listing of the MICRO SWITCH branch office located near you.





The image shown on this Comparator enables engineers to carefully scrutinize tiny parts of a precision switch to check contours and dimensions. This is part of the extra care that preserves MICRO SWITCH precision and reliability.

MICRO SWITCH catalogs are also available on a complete selection of Limit Switches, Enclosed Industrial Switches and Explosion-Proof Switches. Write for the material you need and bring your data files up to date.

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH Precision Switches

Circle 427 on Page 19

Webster hydraulics "muscle" a boardinghouse reach . . .

It stretches way out for a hearty bite, digs deep and unloads high over a truck side. Hydraulics give this versatile backhoe its sure-footed stance, swivel-hipped performance, accurate bucket and boom control. In many of these mobile rigs, a Webster JD hydraulic pump powers the action — in up to seven separate cylinders!

Not an unusual assignment — for the JD series has an uncanny ability to handle demanding jobs with speed, sureness and exceptional dependability. That's why you find them on a wide range of industrial, agricultural and construction machines . . . in pressure lubricating, oil circulating and lift systems.

Webster JD positive displacement, gear-type pumps are available in 5 sizes — from 5 to 23 gpm — with pressures to 2000 psi, speeds to 2400 rpm. Drive is direct, gear or belt. Side porting standard, end optional. Compact design fits into tight corners.

Need help in a specific hydraulic application? A specially trained Webster hydraulics engineer is ready to assist you. Write for action!

JD SERIES POSITIVE DISPLACEMENT GEAR-TYPE PUMP — Send for complete engineering characteristics performance and installation data.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACINE · WIS

HOW THE SILICONES MAN HELPED AMERICA KEEP ITS DATE WITH THE JET AGE

As your jet air liner streaks aloft today, UNION CARBIDE Silicones are aboard to help. Silicones aided in its manufacture, too. The giant tires slipped easily from their original molds because of silicone mold release agents. Polyether foam seat cushions were formed under the near-ideal control of silicone surfactants. Soft, flexible oxygen masks, of oxygen- and ozone-resistant silicone rubber, fit facial contours without irritating the skin. Silicone fluids damp out vibration in vital, sensitive instruments. Silicone rubber door seals never lose resiliency even in extreme temperatures, won't harden or shrink. This constant flexibility makes it the basic material in blankets used for construction of honeycomb structural panels, also in grommets, gaskets, and O-rings. And in the flexible hoses in hot-air jet-engine starters. You'll find jet aircraft radio and radar wires insulated with electrically resistant silicone rubber. Piston plane and helicopter ignition wiring, too. Also the boots for helicopter control sticks, many other parts. This is only a smattering of what silicones have been doing for just one industry—aviation. Is your business enjoying equal benefits? We suggest you contact the UNION CARBIDE Silicones Man. Address: Silicones Division. Dept. HL-0002, Union Carbide Corporation, 270 Park Avenue, New York 17, New York.

Unlocking the secrets of silicones
Rubber, Monomers, Resins, Oils and Emulsions

UNION CARBIDE SILICONES

The term "Union Carbide" is a registered trade mark of UCC. *In Canada:* Bakelite Company, Division of Union Carbide Canada Limited, Toronto 7, Ontario.

Flash butt-welding titanium extruded section eliminates 38 lbs. of material...plus machining

When an extruded shape closely approximates the finished cross-section of a circular part, you can save money—particularly where expensive materials are involved. This titanium ring was circular formed and flash butt-welded from the section shown aboye. Material savings were $262.00 per ring, plus $46.00 on machining.

Amweld is equipped to supply flash butt-welded rings and circular products in stainless, titanium, aluminum, as well as a wide variety of corrosion-resistant alloys. If you would like to know more about Amweld's welding, fabricating and complete machining facilities, phone or write.

GET THE FACTS ABOUT AMWELD

New 20-page catalog describes flash butt-welded rings and circular products manufactured by Amweld. Also booklet entitled, "How Flash Butt-Welded Rings are Made."

AMWELD® INDUSTRIAL PRODUCTS

THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO

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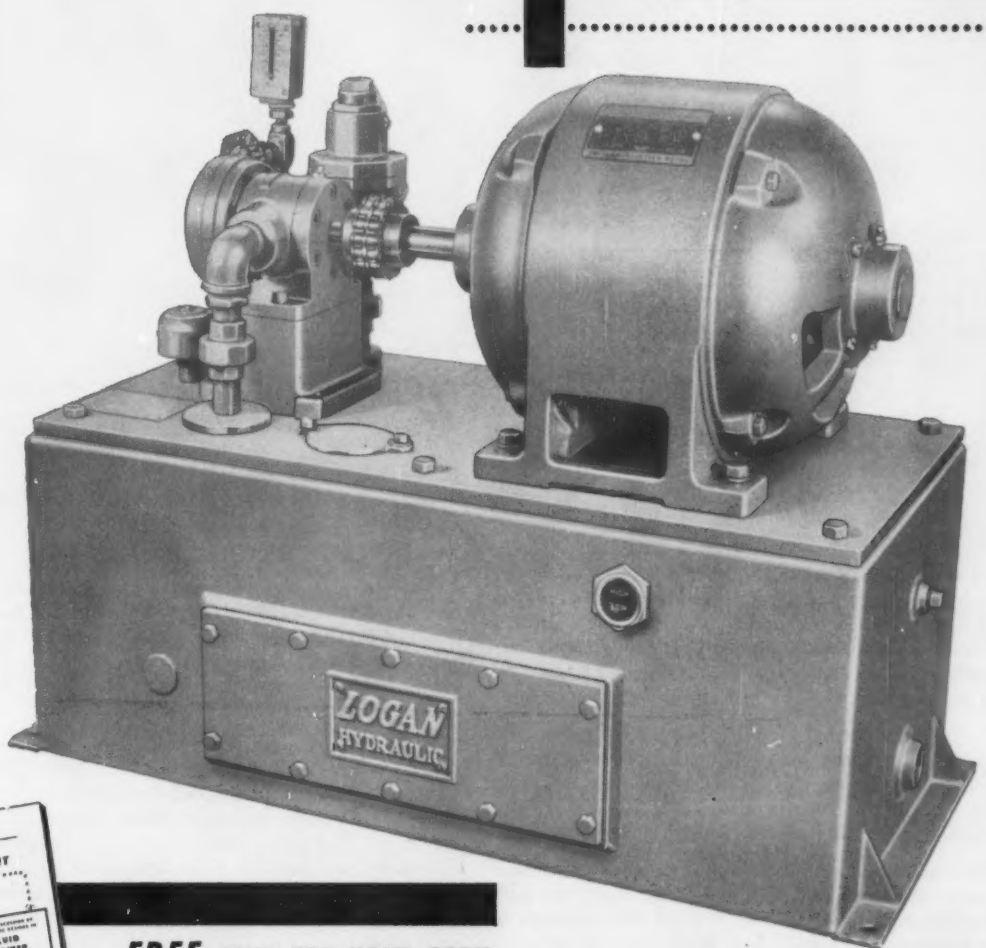
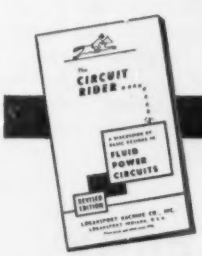


ILLUSTRATED—LOGAN MODEL 6031 HYDRAULIC POWER UNIT



FREE **SEND FOR YOUR COPY OF THE LOGAN "CIRCUIT RIDER"**

A 32-page manual on fluid power circuits (fifth edition) completely revised to present current engineering trends.

MEMBERS: Natl. Mach. Tool Builders' Assn.; Natl. Fluid Power Assn.

Circle 431 on Page 19

DESIGN FACTS ABOUT ABRASION RESISTANCE

Service data show 15-3 alloy offers double the abrasion resistance of pearlitic white irons

• **Pearlitic or martensitic white iron:** which is the more economical for applications involving low-stress abrasion (erosion)? Engineers at Climax Molybdenum have carefully analyzed the service of both types. What they've found proves that the martensitic white irons are frequently more economical because of their longer service. Of these, the 15-3 alloy (15% Chromium, 3% Molybdenum) seems to offer the greatest number of advantages.

• **15-3 alloy shows superior resistance** to scratching abrasion or erosion caused by sharp, free-moving particles. The following test results show wear rates for 15-3 that are markedly lower than those of low alloy white irons having either pearlitic or martensitic structure. In fact, the wear rates for 15-3 are even lower than the rates for high chromium martensitic iron.

RESULTS OF TESTS RUN ON CLASSIFIER WEAR SHOES OPERATING IN SLURRIES OF GROUND SILICEOUS ORE

	Relative Wear Rate
15-3 ALLOY	28
martensitic high-chromium white iron	48
martensitic nickel-chromium white iron	80
pearlitic low-chromium white iron	100
martensitic alloy steel (1.5% C)	180

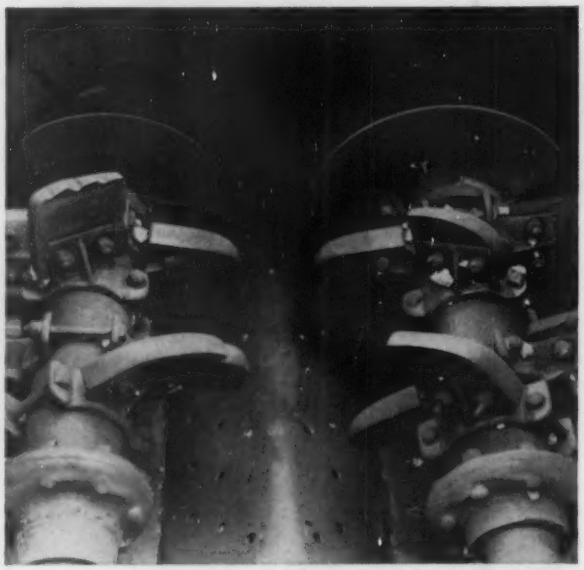
RESULTS OF TESTS RUN ON A CHUTE LINER, 1½" THICK, HANDLING MINUS 3" CRUSHED STONE

	lb/1000 Tons of Ore Handled
15-3 ALLOY	0.22
martensitic high-chromium white iron	0.30
low-chromium pearlitic white iron	0.43
austenitic manganese steel	0.55
pearlitic low-carbon unalloyed steel	1.69

• **15-3 alloy combines toughness and corrosion-resistance with its resistance to abrasion.** 15-3 alloy is able to withstand the moderate impacts that cause low-alloy or unalloyed white irons to break or spall. It's also resistant to corrosion, as applications in sand pumps handling corrosive water have already proved. It should prove superior to soft-rubber parts or rubber liners, too, because it can't be torn by tramp material or corroded by oils and other organic compounds.

• **15-3 alloy is already proving itself more economical** in chute liners, sand pumps, brick molds, impellers, grinding mill liners, etc. In each case, the alloy has more than paid for itself through longer service and lower replacement costs.

• **More information is available on all aspects of abrasion – and abrasion-resistant alloys – from Climax. For your copy of our free 36-page booklet, "The Role of Molybdenum in Abrasion-Resistant Materials", and other data, write:**



Three cases where 15-3 alloy offered longer service life

1. These two sets of pug-mill puddles look alike. But the set on the left has already outlasted three of the gray-iron paddles shown at right. It promises to outlast many more. The reason for this is that the set on the left is made of 15-3 alloy, which offers superior resistance to the erosive abrasion encountered in producing aggregate.

2. Erosive abrasion continually wore out white iron shoes on a spiral sand classifier. Then the mill tried shoes made of a special abrasion-resistant martensitic white iron: 15-3 alloy. These shoes gave three times longer service – thereby providing substantial savings per unit of material handled and also on shutdown time for replacement.

3. Sand pumps must continually withstand severe attacks by erosive abrasives. But making vital parts of 15-3 alloy – such as the follower plates, expeller rings and impellers – has helped the pumps withstand these attacks. In fact, parts made of 15-3 alloy have outlasted martensitic nickel-chromium and pearlitic white iron parts by three to one – when handling abrasive materials such as ground taconite ore. Where corrosive water is present, the improvement is even greater.

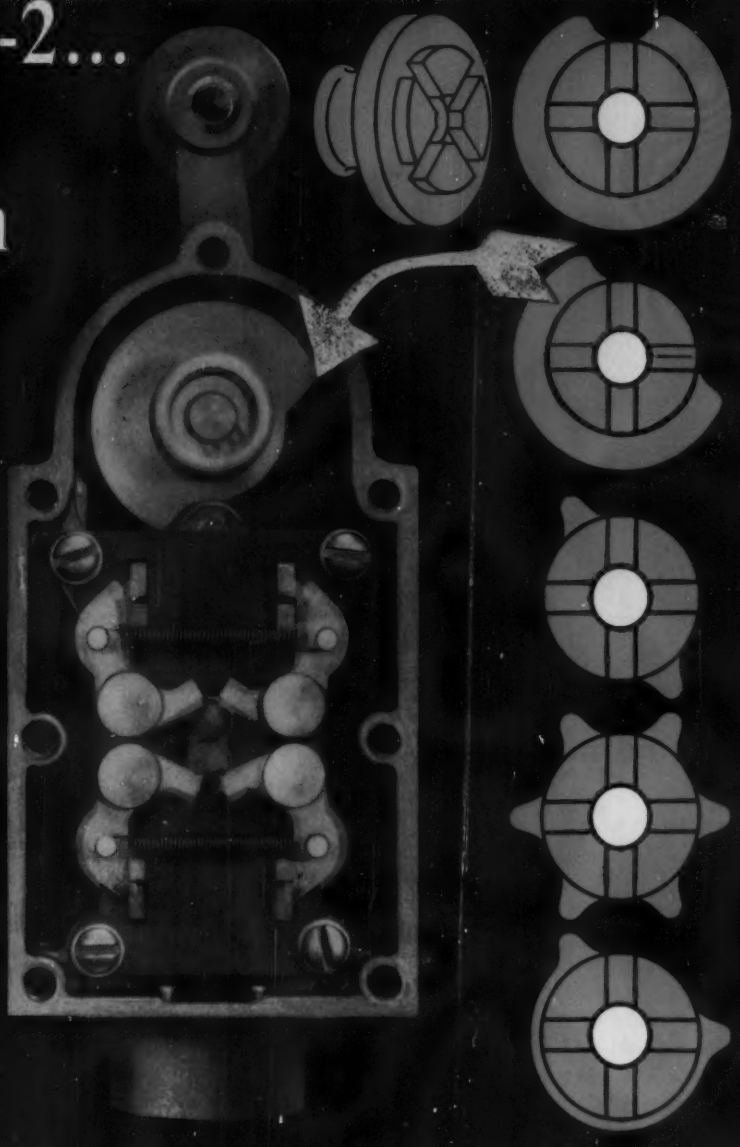
CLIMAX MOLYBDENUM

CLIMAX MOLYBDENUM COMPANY

A division of American Metal Climax, Inc. / 1270 Avenue of the Americas, New York 20, N.Y.

Circle 432 on Page 19

the new SL-2... a standard limit switch with unlimited operating flexibility



Tailor limit switch performance to your specific job with NAMCO'S *standard* SL-2. This "machine life" limit switch features a standard cam blank which can be cut into a wide variety of configurations to meet any application. These interchangeable cams provide positive control of contact sequence; let you match switch operation to your specific job. Ruggedly built, oil-tight and moisture-proof, the SL-2 provides dependable, accurate performance that meets your most precise requirements.

Now available for low-current, high-shock, excessive-vibration applications...the SLS-2... with full-wiping, self-cleaning sliding contacts that insure "everytime" operation under conditions that spell machine downtime for other limit switches.

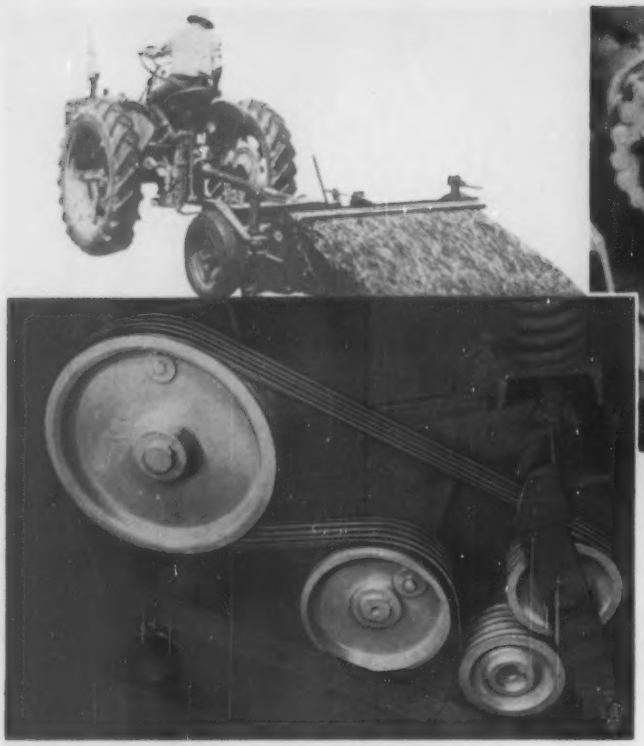
Get all the details on how the NAMCO SL-2 line eliminates limit switching problems for good. Write for Bulletin EC-SL260, or contact one of our representatives. You'll find them in all principal cities.

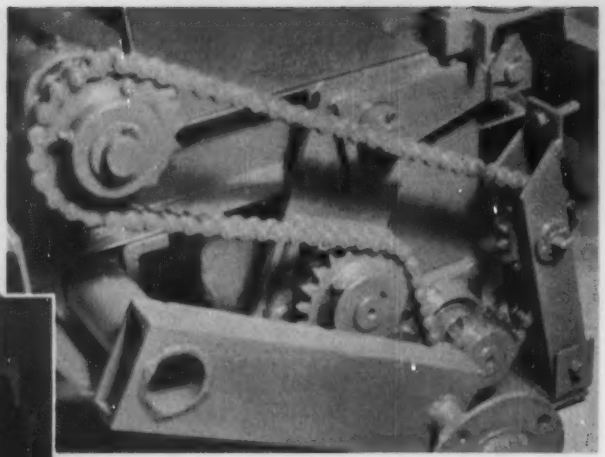
National Acme

THE NATIONAL ACME COMPANY
188 E. 131st STREET
CLEVELAND 8, OHIO

Sales Offices: Newark 2, N. J., Chicago 6, Ill., Detroit 27, Mich.

Circle 433 on Page 19





FORMER DRIVE: The high speed operation of Gehl's Cure-All Hay Conditioner caused failure of the roller chain drive.

PRESENT DRIVE: Both the limited space and high speed requirements were met with this Gates Super HC V-Belt Drive.

Gehl Brothers Manufacturing Company Finds

Super HC V-Belt Drive handles speeds chain drive couldn't take!

Roller chain drives on Gehl's Cure-All Hay Conditioners **"would not stand up under the speed of operation." Yet conventional V-belts that would fit into the space available could not handle the working load for this outstanding line of forage harvesting equipment.**

The design problem remained a tough one until the introduction of the Gates Super HC High Capacity V-Belt early last year. Then the Gates Field Engineer, working closely with Gehl Engineers designed the new drive shown above.

"The Super HC V-Belt Drive has eliminated need for shear pins and clutches, has increased efficiency, and lowered maintenance costs," is the pleased report from Gehl personnel.

Take advantage of Super HC on your equipment

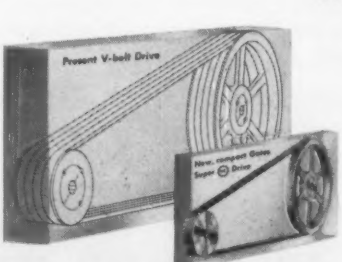
Whenever you have a drive change on a new model or are replacing belts or sheaves, let your Gates Representative show you how Super HC Drives can reduce sheave diameters 30% to 50%, drive space up to 50%, drive weight and cost as much as 20%.

A handbook, "The Modern Way to Design Multiple V-Belt Drives," is yours for the asking. Simply contact your Gates Representative listed in the Yellow Pages.

TPA 505

The Gates Rubber Company, Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ontario

Gates *World's Largest Maker of V-Belts*



Gates Super HC V-Belt Drives

same hp capacity in smaller "package"

stitching together a giant radome

Radome designed and built by Long Sault Woodcraft Limited, St. Andrews East, Quebec, for the United States Air Force RADC.

Looking upward from the inside of the world's largest stressed skin sandwich radome built of translucent fiberglass panels, securely joined by hundreds of DUAL-LOCK fasteners.

Radar antennae along the upper perimeter of North America's defense system are enclosed by protective domes which stop ice, snow, and gales up to 150 mph.

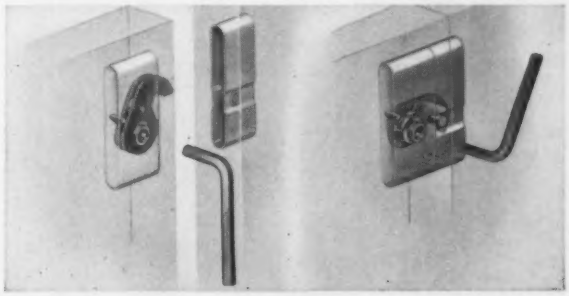
This precisely engineered pattern of fiberglass panels is erected quickly and surely, under the most adverse field conditions, using recessed Simmons DUAL-LOCK fasteners.

DUAL-LOCK is ideally adapted to panel fastening for military shelters, demountable shipping containers, aircraft cowlings and guided missiles.

Features:

- High load characteristics. The standard No. 1 DUAL-LOCK withstands 2500-lb. tension, and with modifications, tension loads of 7000 lbs. and over.
- Double-acting take-up provides great closing pressure, with minimum pressure on operating tool.
- Positive-locking. Trigger action insures fully open and fully closed positions.
- Vibration-proof and impact-proof. Will not accidentally unlock or loosen.

Write for catalog #1257. Complete specifications, drawings, details of DUAL-LOCK and other Simmons Fasteners with unlimited money-saving applications.



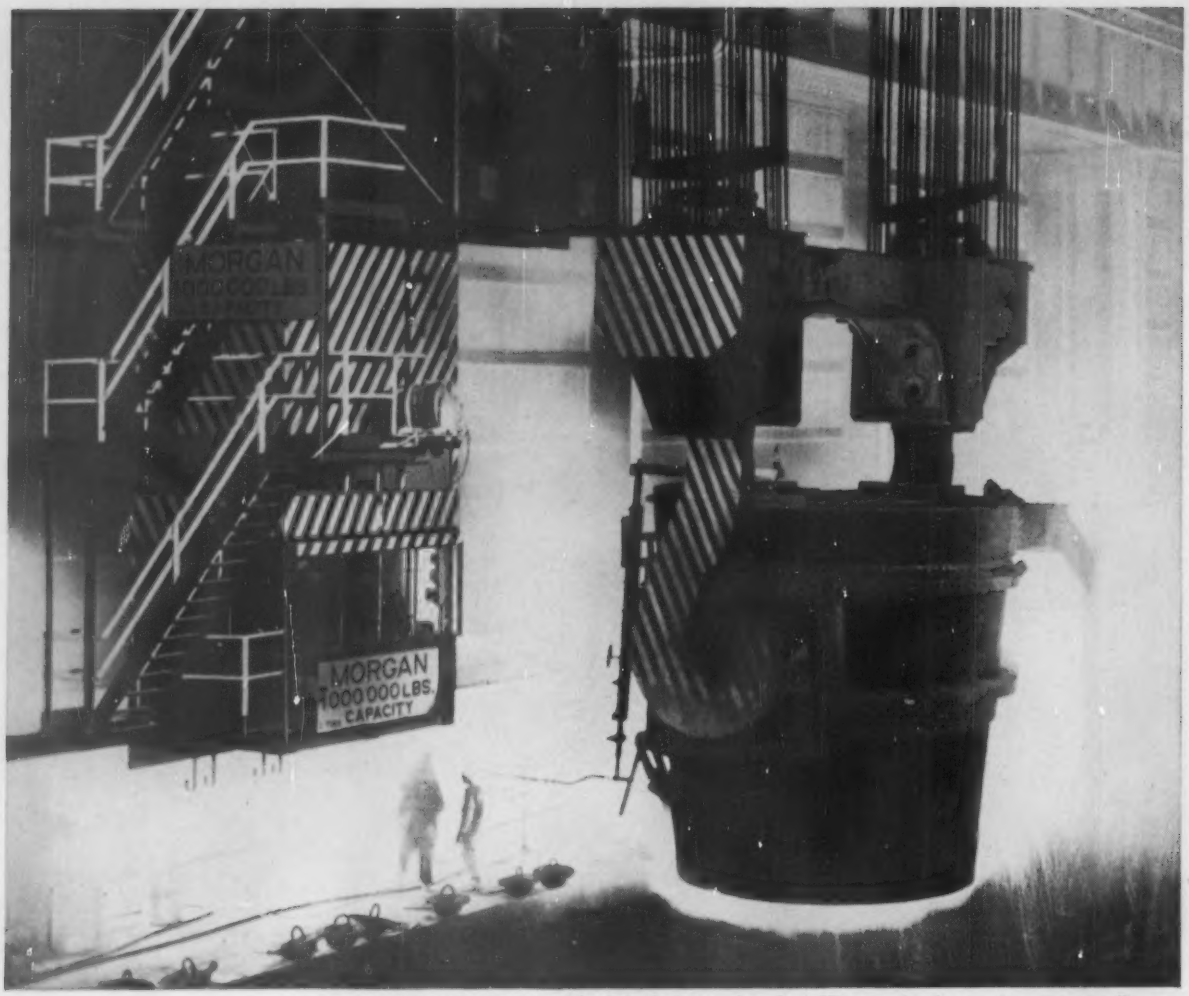
SIMMONS FASTENER CORPORATION

1756 North Broadway, Albany 1, New York

See our 8-page catalog in Sweet's Product Design File

QUICK-LOCK • SPRING-LOCK • DUAL-LOCK • ROTO-LOCK • LINK-LOCK • HINGE-LOCK

Circle 435 on Page 19



Repeated million-pound loads in the intense heat from 375 tons of molten steel, cause no spalling or deformation of Rollway Bearings.

1,122,000 Pounds Ride on 68 Rollway Bearings

One of the largest in the world, this 500-ton Morgan-built ladle crane is Rollway equipped in many positions.

Sixty-eight maximum-type, solid-cylindrical bearings—mounted without inner races—lift and lower the 1,122,000-pound weight of the lifting beam, ladle hooks, ladle and white-hot steel.

Rollway Tru-Rol® type bearings are used in the two General Electric 360 HP – MD-620 Hoist motors which lift the weight of the ladle and its molten metal content.

The maximum-type bearings in the hoisting sheaves are mounted directly on the shaft without inner races, which greatly simplifies assembly for applications of this size.

Thrust bearings in the 25-ton and 75-ton auxiliary crane hooks are standard Rollway precision types with broad-area contact between rollers and plates to prevent Brinelling and assure freedom of rotation under the heaviest loads.

Sheaves ready for assembly on shaft and installation in lifting beam.

For bearings that accomplish the extraordinary in an ordinary manner, write, wire or 'phone Rollway Bearing Co., Syracuse 1, N.Y.

ROLLWAY® BEARINGS

ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Seattle • Houston • Philadelphia • Los Angeles • San Francisco

Quality control at Standard is second to none among the nation's major specialty product steel plants. It is maintained by the most accurate, up-to-date testing equipment available. The laboratory facilities operate around the clock to keep all vital information flowing to our metallurgists, shop foremen, mill and machine operators—as well as to plant management, and, of course, our customers.

Bring your next unusual product to us—we'll welcome the opportunity to serve you regardless of the alloy it might require. Send for the free illustrated booklet, "Quality Control at Standard."

Standard Steel Works Division
BALDWIN · LIMA · HAMILTON

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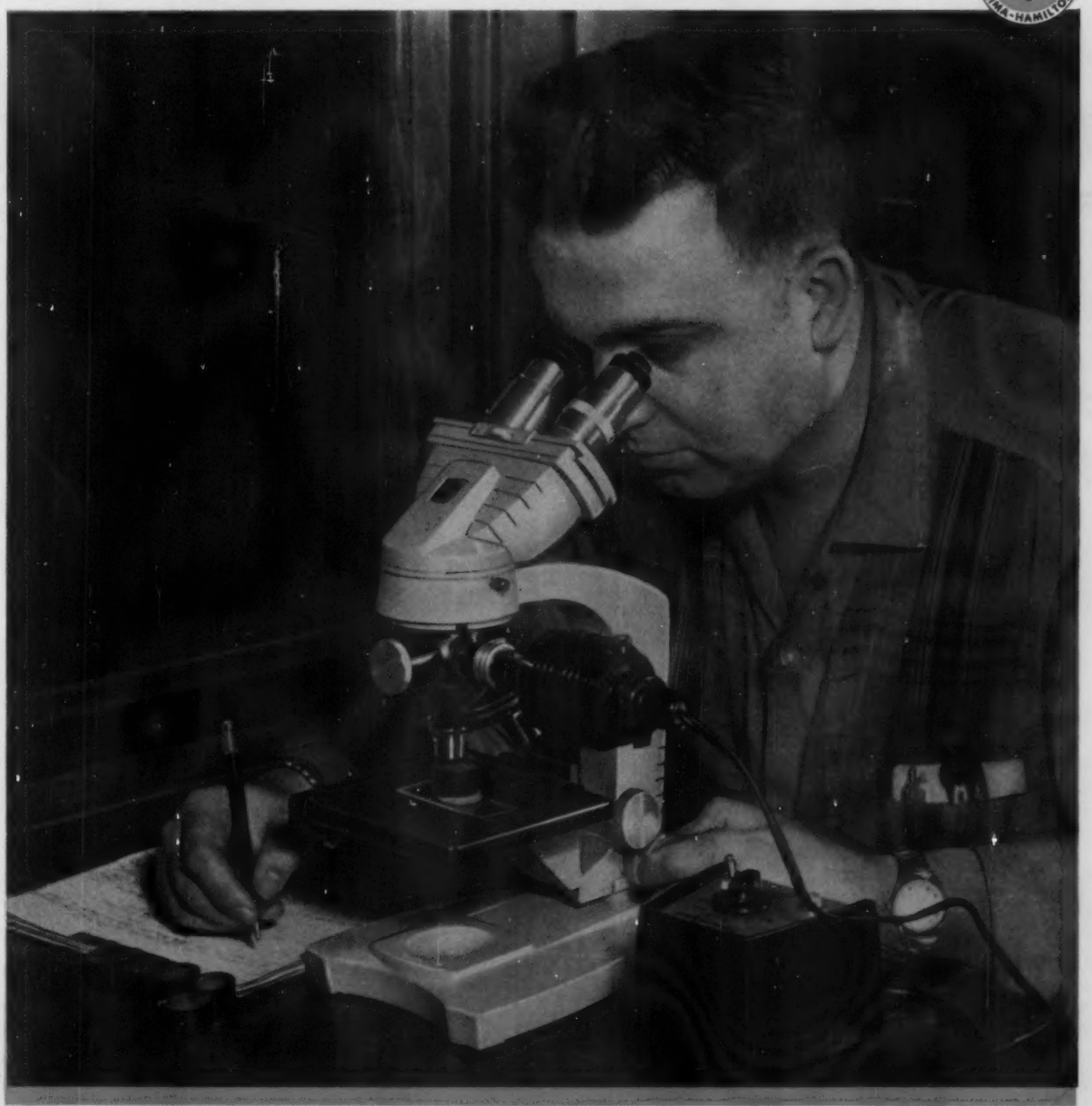
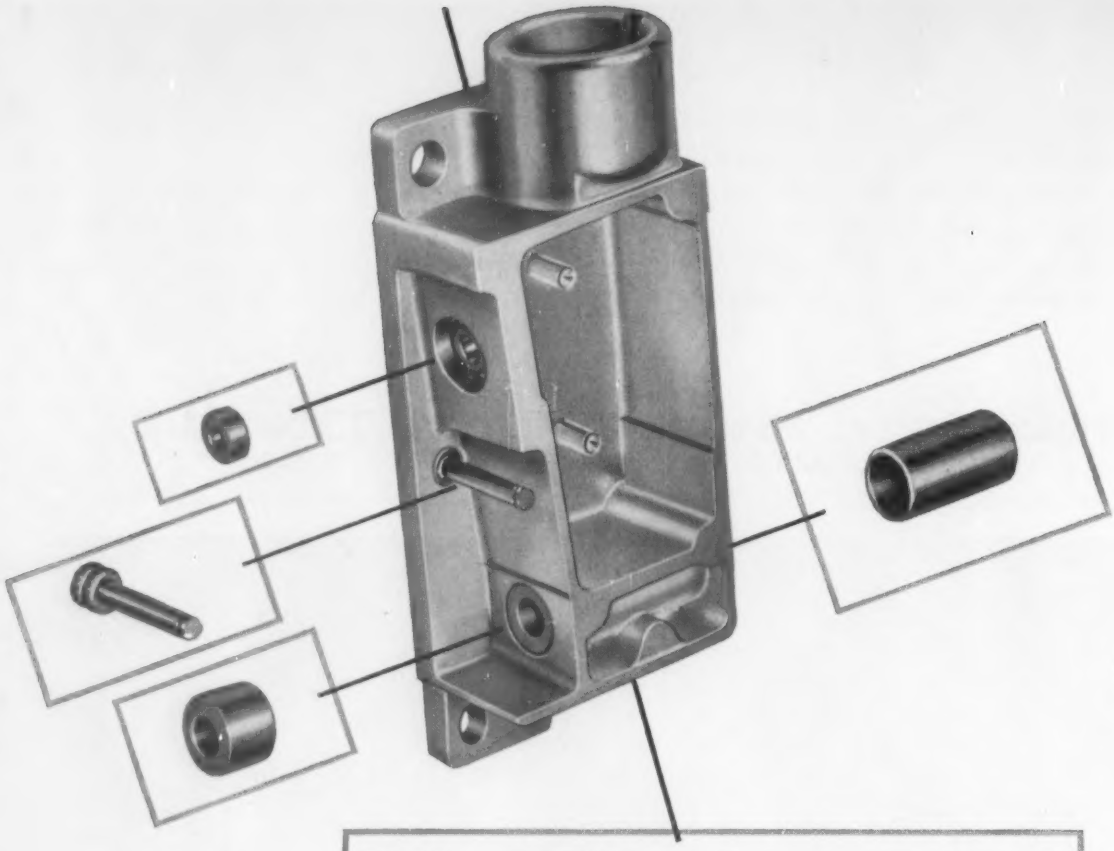
Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes





"Hot-Shot Assembling"

with MADISON-KIPP zinc and aluminum die castings

"Hot-shot assembling" is a shop term but it is literal, because inserts are put in place and liquid metal under high pressure is shot into the die to surround and anchor the inserts in the die casting.

In many cases the advantages of cast-in inserts provide substantial cost savings even though the casting process is slower than when no inserts are involved.

The seasoned and skilled Madison-Kipp mechanics have had long experience in "hot-shot assembling." They may be able to assist you in your problems.

Please clip this ad as a reminder to contact us when you have die casting requirements.

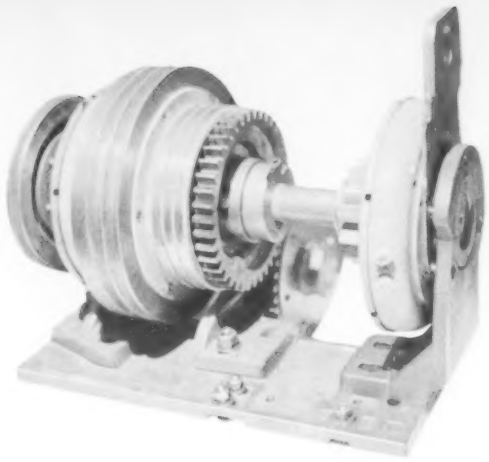
kipp

MADISON-KIPP CORPORATION
210 WAUBESA STREET • MADISON 10, WIS., U.S.A.

Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

Circle 438 on Page 19

Circle 439 on Page 19→



Crompton & Knowles pioneers highly controlled weaving with Warner electric brakes and clutches

Imagination and Warner electric motion control can produce major technical achievements, even in the highly advanced textile industry.

Crompton & Knowles Corporation, Worcester, Mass., proved it by turning a simple electromagnetic drive into a versatile control system for their new C-7 loom. Repeat orders evidence the importance of the development, benefits of which are impossible to duplicate in a practical manner with any other type of drive:

1. *Pushbutton control*—Direct conversion of electrical signals into mechanical motion gives fast, easy pushbutton stop, start, backup or single-pick operation.

2. *Foolproof interlocking*—Prepositioned rotary switch prevents braking in an unsafe portion of the weaving cycle.

3. *Cushioned operation*—Electric protection provides time for softer stops, prevents jarring the machine out of "fix."

4. *Increased work assignments*—Pushbutton control reduces fatigue and shortens stop intervals, leaving operator more time for weaving.

5. *Reduced maintenance*—Fewer critical parts of adjustment. All mechanical protection parts and linkages are eliminated.

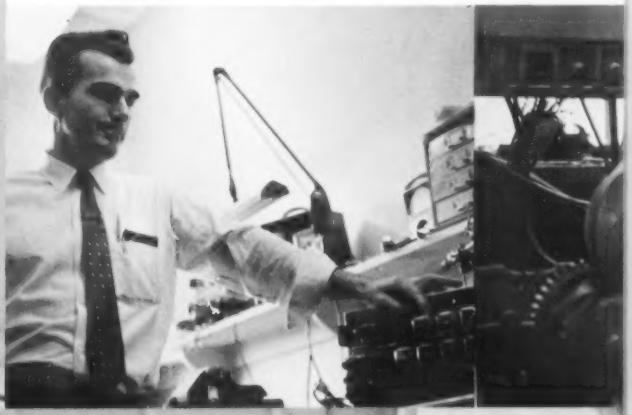
6. *Fail-safe operation*—Precocked brake stops loom safely in event of power failure.

7. *Reduced skill requirements*—Inexperienced weavers can operate the loom safely at highest speeds.

Albert Palmer, Vice President and Director of Engineering—The big advantage is sensing electrically and controlling directly through an electromagnetic drive.

Fred Paul, Electrical Engineer—Capacitor in the control circuit for overexcitation and fail-safe operation of the brake.

Warren Snow of Warner unit



Victor Sepavich, Manager, Research and Development (left)—Designs to increase productivity of **average** mill workers.

WARNER ELECTRIC

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8. Improved operation—Flywheel effect provides steadier operation, especially picking.

Shuttle speed determines how fast you can operate a loom. This makes it difficult to design a machine which justifies replacement of existing equipment. Total mill operating costs must be understood and considered.

The problem is stated well by Mr. W. C. Howe, Northern Sales Manager, when he says mill operators today cannot afford to be in a *marginal* position. Foreign competition is one of the reasons textile mills want the best machines they can get.

The same philosophy is echoed in engineering. Mr. Robert Schedin, Chief Engineer, points to the importance of *intangibles*—factors that don't show up in replacement formulas. He explains that anything which disturbs the balance of the operation restricts the number of looms one person can handle. And they must play a part in product planning.

With these criteria in mind, Victor Sepavich, Manager, Research and Development, planned the electromagnetic drive around two unique control objectives—both important *extra* advantages from an otherwise conventional application of Warner electric brakes and clutches:

Prepositioned control prevents unsafe braking

When a loom stops in the wrong part of its cycle, the shuttle can be thrown into free flight and "smash" through woven fabric, causing long downtime of the machine. By using a prepositioned rotary switch it is possible to actuate the brake only during the safe portion of the weaving cycle. The drive stops the loom in from 40 to 60 milliseconds.

For the same reason, a power failure can be a costly nuisance to a mill. Protection against this nuisance is provided by a capacitor in the C-7 control circuit. This stores enough energy to operate the brake *independently* in the *safe* portion of the cycle. In normal operation, it is used for overexcitation of the brake magnet, making possible 5 to 10 millisecond actuation.

Textile machine buyers look at controls first, so why not put proved performance where your customers see it?

Electric motion control by Warner is pioneering important new concepts in machine design. Direct electrical actuation makes it easy to control: synchronization of multiple drives; fast, automatic cycling; fine-increment inching and jogging; no-load starting; rotary and linear positioning; and other complex functions your customers look at closely when buying capital equipment. Your Warner sales engineer can demonstrate these features right on your desk top.

WARNER ELECTRIC

Warner Electric Brake & Clutch Co.
Beloit, Wisconsin

Snow, Manager Quality Control—100% inspection er units on a test stand simulating loom conditions.

Robert Schedin, Chief Engineer—New control is "protective motion." Soft stops help keep loom in adjustment.

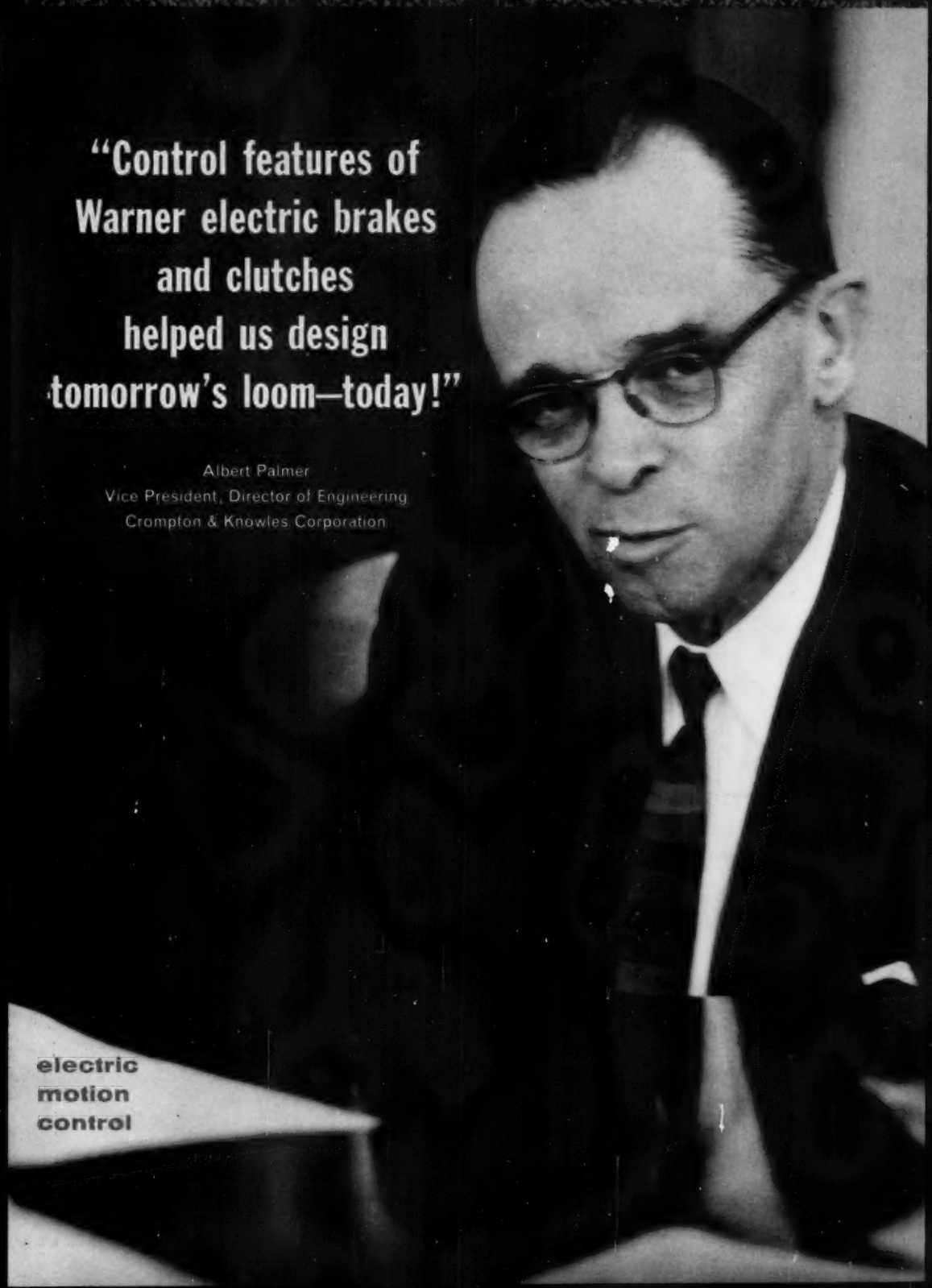
W. C. Howe and H. F. Smith, Sales—Electric brake and clutch features are key to ability of C-7 loom to pay for itself.

to

Joseph Benoit and E. W. Malbon, Purchasing—Warner's facilities and "know-how" pinpoint precisely our production schedules.

Product Improvement Ideas from

WARNER ELECTRIC



"Control features of Warner electric brakes and clutches helped us design tomorrow's loom—today!"

Albert Palmer
Vice President, Director of Engineering
Crompton & Knowles Corporation

electric
motion
control

boasting

The cat and the fox were walking through the woods together. "Man seems to want me very much," boasted the fox. "Sometimes many men on horses and many dogs come after me, but I fool them with a hundred different tricks. They don't catch me!" // "That's all very well for you," said the cat, "but when I'm in danger the one thing I can do is run up a tree." // "I don't see how you are still alive," said the fox. "I'll teach you some of the many different ways I know of staying safe." // Just then they heard the cry of the dogs. The cat ran up a tree as fast as she could and hid among the leaves. The dogs chased the fox through the woods. He tried to fool them with each of his very best tricks, but soon he grew tired and the dogs drew closer. At last the dogs jumped on the poor fox and killed him. // Then the cat climbed down out of the tree and went safely home.

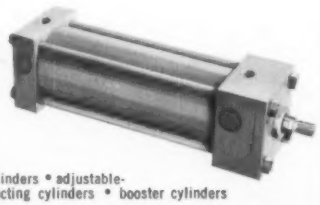
moral: One solution to a problem is good enough, if it's the right solution.

We hope machine downtime isn't your problem, but it does happen. And when inadequate cylinders are the cause, *one* solution is good enough. Sure, we're talking about Hydro-Line—one source of cylinders for hydraulic applications up to 5,000 psi, and air operations up to 200 psi.

Standard stock cylinders usually will be your right solution . . . they have all catalog stock dimensions, cost 10% less than custom cylinders, and are delivered quickly from stock. If modified designs are needed, we have as wide a range of modified standard cylinders as is available.

Look in *Sweet's Product Design File* (Bulletin 8a/Hy) for standard dimensions of stock cylinders and the address of your nearest Hydro-Line representative. Then ask him for the right solution to your cylinder requirements.

HYDRO-LINE CYLINDERS



5600 PIKE ROAD • ROCKFORD, ILLINOIS manufacturers of:
high- and low-pressure hydraulic cylinders • heavy-duty air cylinders • adjustable-stroke cylinders • dispensing cylinders • intensifiers • single-acting cylinders • booster cylinders

RESEARCH AERIAL PLATFORM will have high degree of civilian utility. Transmission system, whose component parts act as power units and structural members, employs 4340 and 4620 nickel alloy steels for shafts and gears.

Aerial platform's unique transmission system uses two nickel alloy steels—4340 and 4620

This experimental aircraft combines the maneuverability of a helicopter with the load-carrying capacity of a truck.

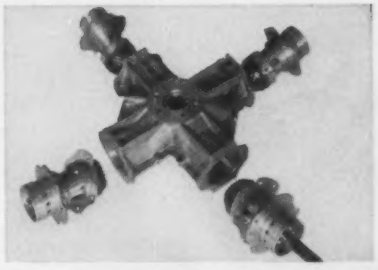
The platform is built around a unique transmission system whose components act as both power units and structural members. Designed jointly by Curtiss-Wright Corporation and Sargent Engineering Corporation, its builders, the platform uses a 400hp gas turbine engine to power four 2-blade propellers through a central gearbox arrangement.

For the gears, the designers specified carburized and hardened AISI Type 4620 nickel alloy steel in the central gearbox and in each of the propeller gearboxes. At every running speed, case-hardened gears of 4620 alloy steel withstand friction and wear. What's more, 4620 gear cores are tough enough to absorb any sudden shock-loads that may occur during flight.

For the propeller shafts, the specifications called for AISI 4340 nickel alloy steel, heat-treated to 30-35 Rockwell C. This versatile through-hardening steel provides exceptional toughness and fatigue strength, and is noted for its superior machinability at high hardness levels. In addition, AISI 4340 steel develops uniform hardness throughout parts of medium to heavy section, despite variations in section size.

The men who designed the aerial platform couldn't predict all the complex stresses these parts would encounter in operation. They selected 4340 and 4620 because these steels have *proven* their reliability and versatility during many years of service, under a variety of strenuous operating conditions.

Whether or not you, too, are experimenting, 4340 and 4620 offer you the same assurance of reliability . . . plus a way to cut costs by simplifying inventory. These steels are available right off the shelf at your local Steel Service Center. Other nickel-containing steels, providing more specialized properties, are also widely available.



EXPANDED VIEW of central gearbox shows how 4620 nickel alloy steel gears fit into box and drive the four propellers.

Consider nickel alloy steels for gears, shafts, bearings and other parts you design, order or use. And for information to help you select the right material for your application, just write us.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES STEEL PERFORM BETTER LONGER

←Circle 437 on Page 19

bend, stamp, cut,
and form away!
this handsome pre-finish
stays put

VINYL-ON-METAL is cooperative. Stamp it out. Punch it out. Even weld it! Form it the same ways you form unfinished sheets. The unique colors, textures and patterns of Vinyl-on-Metal sheeting or coils remain unaffected. The tough resilient surface stays—won't chip or peel in use. It protects against tearing or wrinkling—minimizes surface damage during fabrication and assembly. Vinyl-on-Metal is already widely and successfully used for furniture appliances, transportation interiors, building construction, and in many other fields. For a highly informative booklet, "Vinyl-on-Metal," write to Monsanto Chemical Company, Plastics Division, Room 753, Springfield 2, Mass.

Monsanto developed and today supplies Opalon® and Ultron® vinyls for superior finishes on steel, aluminum, and other metals, and on wood, paper and glass.

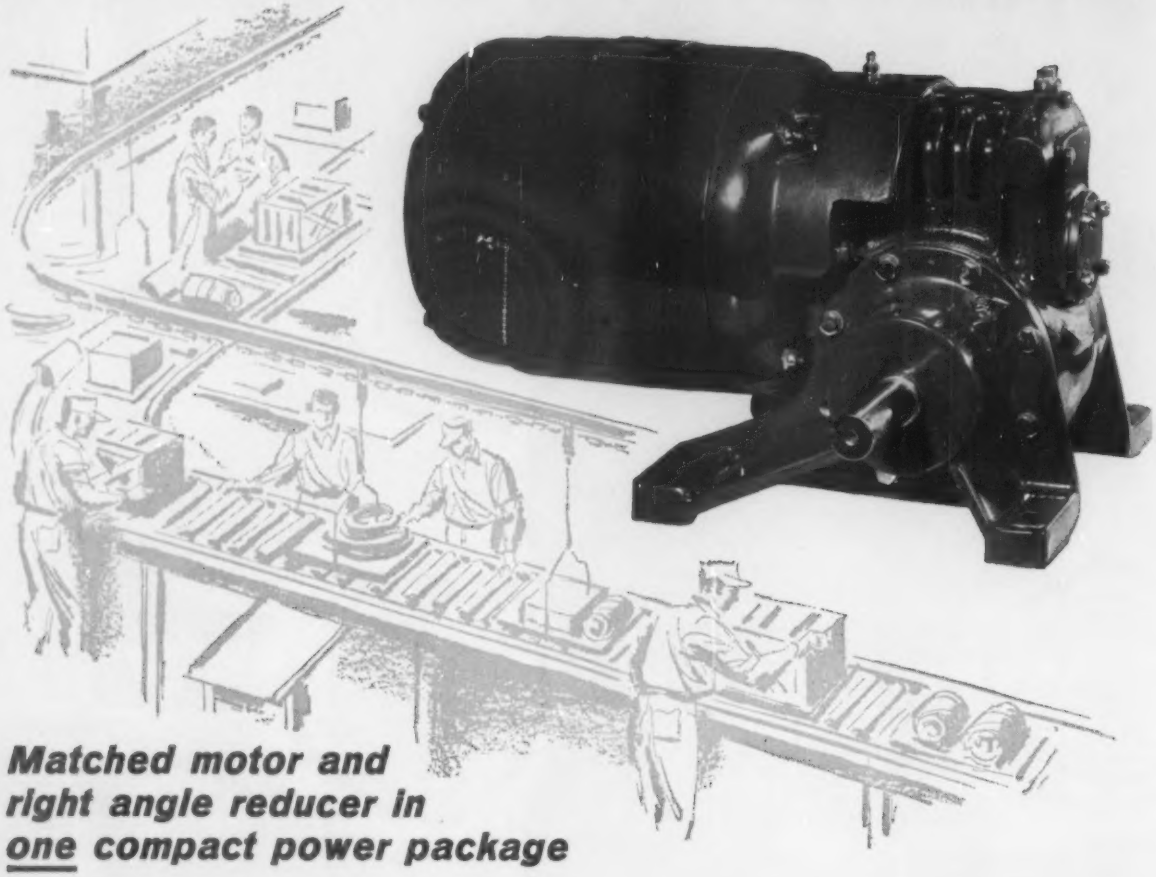
MONSANTO DEVELOPER IN PLASTICS

Monsanto

Circle 440 on Page 19

MASTER GEARMOTORS

simplify applications—save space



Matched motor and right angle reducer in one compact power package

Reduction of engineering and assembly cost . . . elimination of separate components . . . are basic in this Master Right Angle Gearmotor. Consider these specific advantages:

1. No high speed coupling.
2. No V-belts or chains and sprockets.
3. Takes up less space—reduces mounting plates.
4. Special flange or face mounting can eliminate low speed coupling.
5. Saves aisle space . . . drives around the corner.
6. Wide acceptance by machine builder and user.

Master Gearmotors are built with ratings from ⅛ to 125 h.p. . . . in right angle, parallel or in combination. Right angle ratios are available to 96:1; parallel 120:1.

Electrical and mechanical modifications give you a maximum choice—vertical, horizontal, and flange mountings; output shaft over, under, left or right. These gearmotors can be supplied with built-in accessories: a fluid coupling for hard-to-start loads or cycling loads; a brake for fast stops and positive holding.

Call your nearest Reliance Sales Engineer. Let him tell you why more Master Gearmotors are in use today than any other make. E-1643

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 288A, CLEVELAND 17, OHIO

Canadian Division: Toronto, Ontario
Sales Offices and Distributors in Principal Cities

Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V★S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.

Circle 441 on Page 19

Circle 442 on Page 19→

working with

Du Pont Zytel®

NYLON RESINS

one of Du Pont's versatile engineering materials

Turbine fan of ZYTEL® makes possible radical design

A difficult design problem in Sunbeam's new de luxe vacuum-cleaner line involved the turbine brush sweeper accessory. The turbine brush combines the advantage of a power-driven brush, previously found only on uprights, with the power and flexibility of a tank-type cleaner. This brush is powered by a unique one-piece fan wheel made up of 54 curved blades, spaced to allow the intake of metallic objects such as paper clips, hairpins and the like.

For satisfactory operation of this turbine wheel, an exceptional material was required—one with high strength in thin sections, resilience, and resistance to metallic impact. The material had to be intricately molded to close tolerances in an economical one-piece molding. In addition, lightness of weight, abrasion resistance, and good bearing properties were needed. The solution: a wheel molded of Du Pont ZYTEL nylon resin, which fulfilled all these requirements. The successful design of this component, molded by Chicago Molded Products Corporation, for Sunbeam Corporation, both of Chicago, Illinois, also permitted the over-all design of the sweeper unit with a low profile for maximum furniture clearance.

On the following page, you will find some additional examples of the basic design improvements made possible by the use of ZYTEL nylon resins.

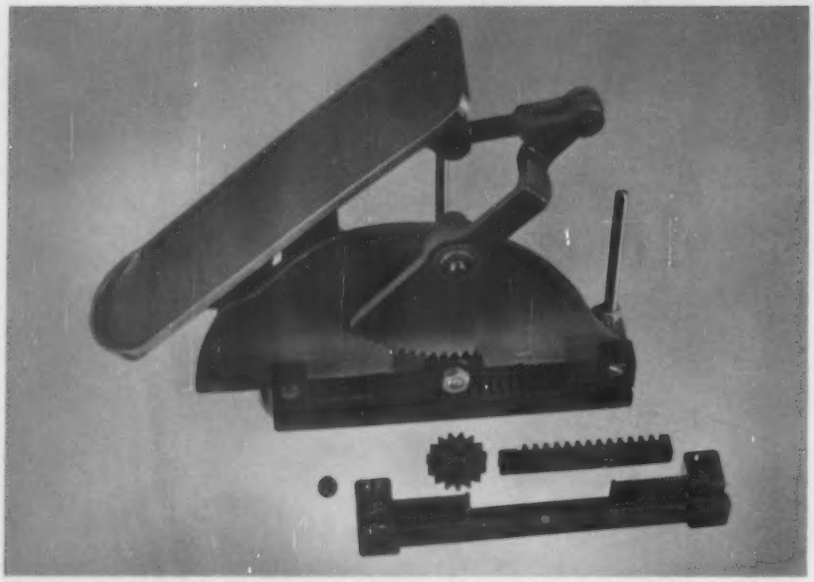
DU PONT
REG. U.S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

working with

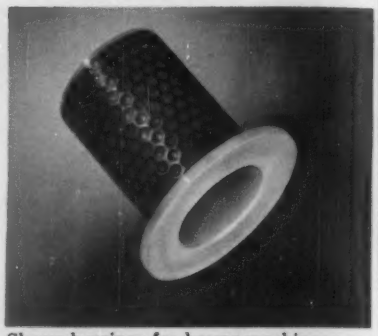
Du Pont Zytel®

nylon resins

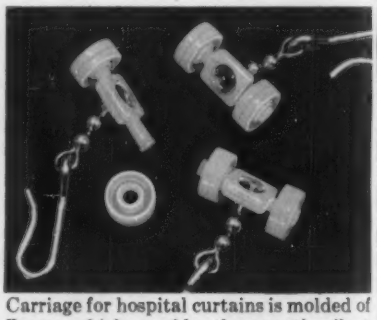
one of Du Pont's versatile engineering materials



Full-throttle foot control for motor boats is made with gear, rack, guide panel and anchor ball of ZYTEL nylon resins. The rack and anchor ball have threads molded in to accept the control cable and sheath respectively. The use of ZYTEL assures smooth, quiet operation of the foot control, and eliminates salt-water corrosion problems. In addition, the unit requires no lubrication. (Molded by Nylon Products Corporation, Clinton, Massachusetts, for Tempo Products Company, Cleveland 3, Ohio.)



Sleeve bearings for heavy machinery are made with sleeves of ZYTEL, reinforced with a steel backing that has indented perforations and press-fits into the bearing housing. The good flow characteristics of ZYTEL enable it to flow easily into place through and around the many perforations. ZYTEL provides the necessary abrasion resistance, impact strength and low noise factor. (Molded by Terhorst Manufacturing Company, Minot, N. D.)



Carriage for hospital curtains is molded of ZYTEL, which provides the smooth, silent operation required in hospitals. This long-wearing part is easily assembled by snap fitting, needs no lubrication. (By Capital Cubicle Company, Brooklyn, New York.)

Designed with ZYTEL®
for smooth, quiet operation

The products on this page demand smooth, low-noise operation, as well as varying degrees of strength, abrasion resistance, corrosion resistance, and freedom from lubrication problems. In each case, the use of ZYTEL meets the combined design requirements and helps assure long, trouble-free operation.

Du Pont ZYTEL may help you, too, to save money by reducing production costs and giving improved performance under a variety of difficult conditions. Find out how by sending in the coupon. Also, ask for the new booklet on the properties and advantages of tubing of ZYTEL.

POLYCHEMICALS DEPARTMENT

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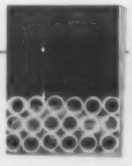
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*



E. I. du Pont de Nemours & Co. (Inc.)
Room 2507Z, Dept. B: 1 2 3
Nemours Building, Wilmington 98, Delaware.

☐ Please send me the booklet on tubing of ZYTEL.
☐ I am interested in evaluating ZYTEL for the following use:

*Name*_____

*Company*_____ *Position*_____

*Street*_____

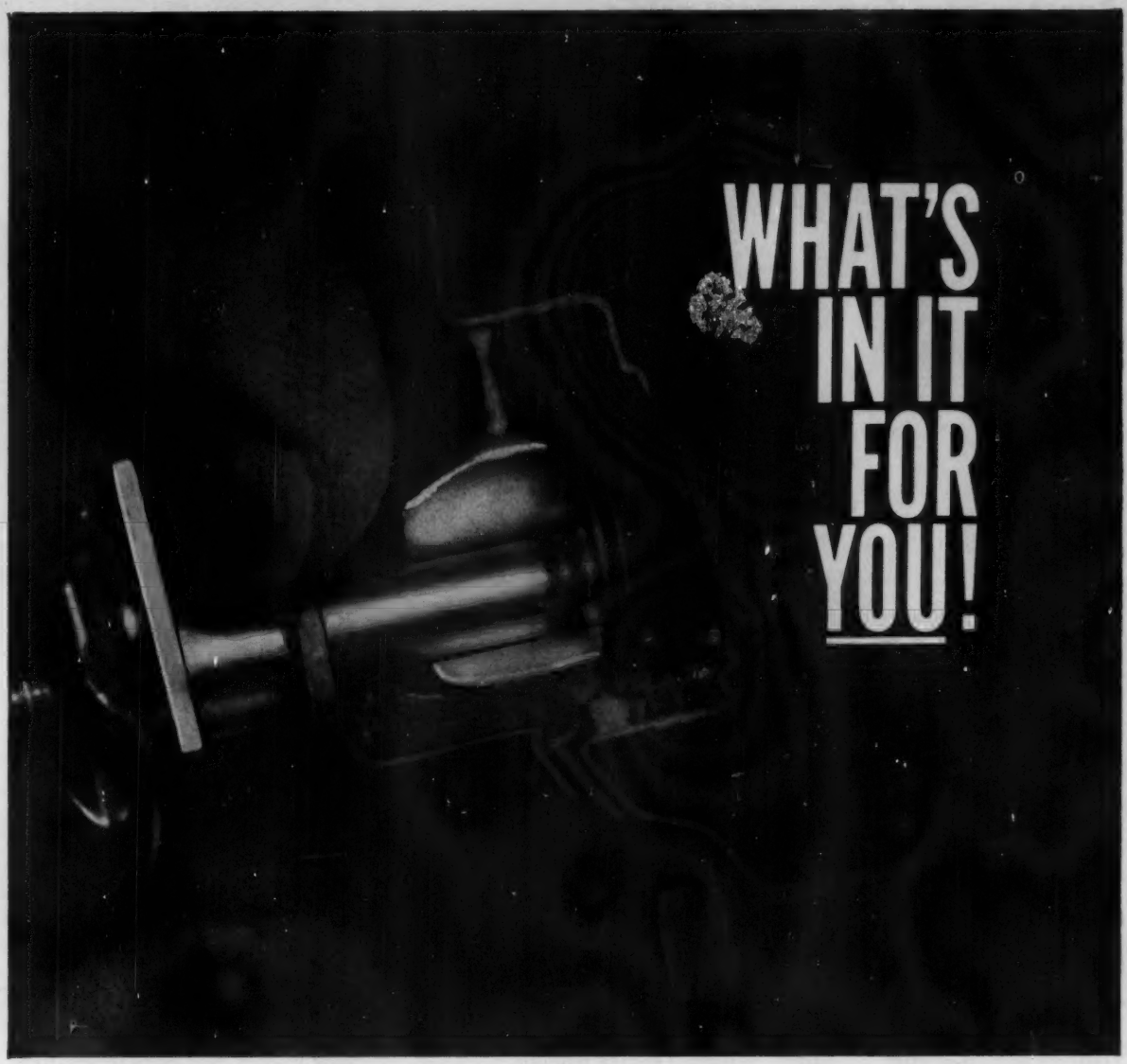
*City*_____ *State*_____

In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

ZYTEL® *nylon resins*

one of Du Pont's versatile engineering materials

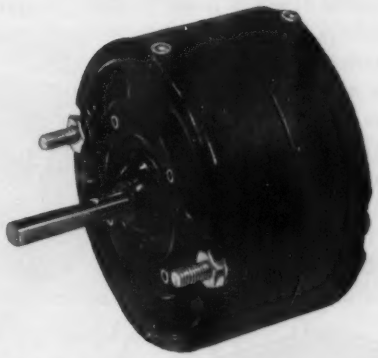
Alathon · Delrin · Lucite



BEARING DESIGN OF **EMERSON ELECTRIC MOTORS**

Is Self-Oiling, Self-Aligning to assure Free Starting and Smooth Operation at all times

–The bronze bearing in Emerson Electric Motors has thousands of tiny cells that cause the bearing to act as a metal sponge and feed the shaft journal a controlled flow of lubricant. In cooling, it draws off excess oil to give free starting at low temperatures. Self-Alignment minimizes friction and greatly increases motor life when you install *Emerson Electric Motors* in your appliances and equipment. Emerson Electric Motors are custom-engineered to meet your specific needs. Call us *today* . . . you'll like our way of doing business!



EMERSON ELECTRIC *of St. Louis • Since 1890*

DEPT. M34, 8100 FLORISSANT • ST. LOUIS 36, MO. • CO 1-1800

←Circle 442 on Page 19

Circle 443 on Page 19

Another new development using

B.F.Goodrich Chemical *raw materials*

USING TWO HARDNESSES OF HYCAR

these skate wheels play a dual role

Hard on the outer edge for longer wear; softer on the inner edge for better traction, less noise. The two shades of color you see in these roller skate wheels show how two different Hycar nitrile rubber compounds are used to serve different needs in the same product.

The outer 3/16" of each wheel is a phenolic compound made with extra-tough Hycar rubber for better abrasion resistance. The inner portion of the wheel is made from a softer Hycar phenolic compound. The two are inseparably bonded during molding.

In addition to providing extra wear and other advantages, in other applications Hycar also provides excellent resistance to oils, chemicals, and gasoline. It is often the key to improving a product or opening a new market. For more information, write Dept. FO-4, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

PREMIER *for professional skaters, and RENTAL, for rinks that rent out skates —wheels are made using two different Hycar nitrile rubber compounds by Fo-Mac Enterprises, Tulsa. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber.*

Hycar
REG. U.S. PAT. OFF.
Rubber and Latex

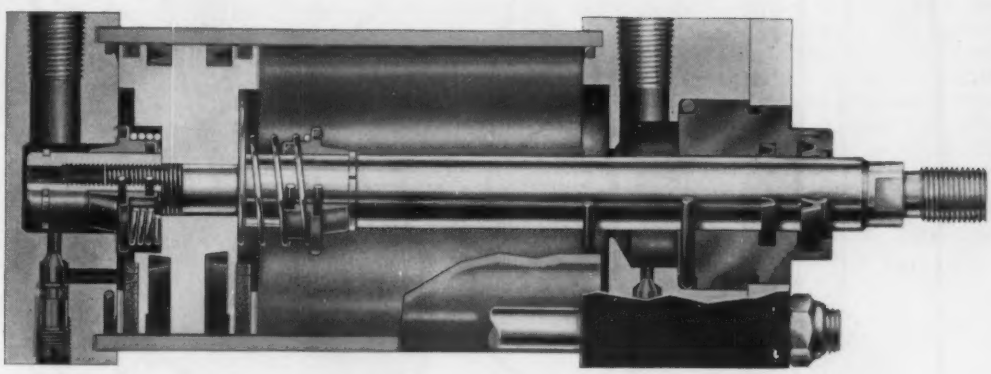
B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

**See our catalog in Sweet's Product Design File.*

B.F.Goodrich

GEON vinyls • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers

Premiering...



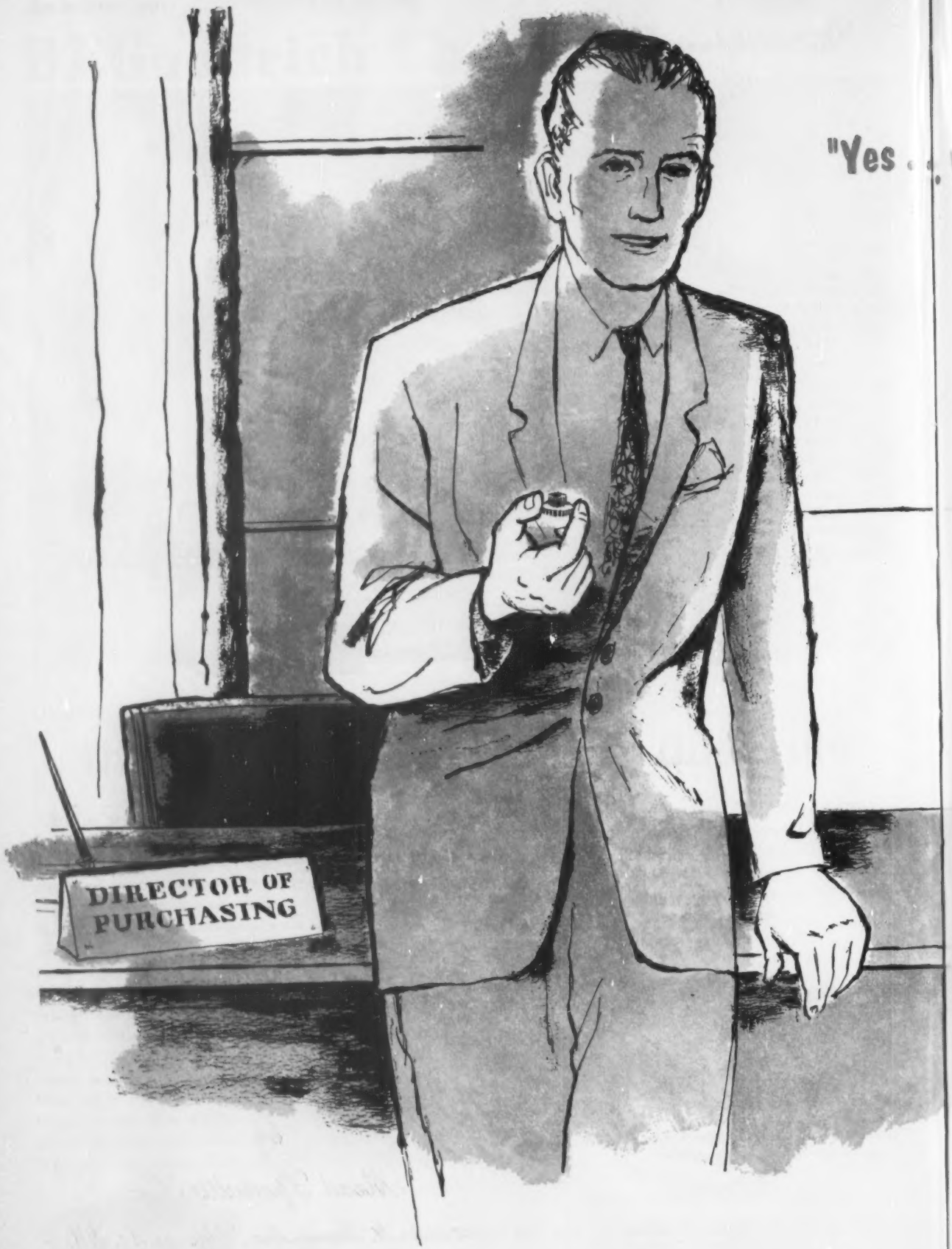
dimensionally interchangeable
square-end air and hydraulic cylinders

by

Mead Specialties Co.

4114 N. Knox Ave., Chicago 41, Ill.

Circle 445 on Page 19


"Yes . . . W
DIRECTOR OF
PURCHASING

"We depend on G.S. for our Precision Gearing!"

"It's just a matter of logic—and good business. You see, we produce rather complex mechanisms. They have to hold up under all kinds of tough conditions in the field. And since Precision Gearing is at the heart of our units, that's the one place we have to *know* that the quality and accuracy of components are consistently right.

"G.S. produces our Gearing to close-tolerance specifications—and we've found that their respect for max. and min. is, if anything, even greater than our own. They deliver our Gearing the *same* from run to run, which keeps our production line moving right along—we don't have slow-downs because of Gearing variations. And failure in the field from Gear trouble is almost unheard of; that means a lot in customer satisfaction, not to mention saving servicing or replacement expense.

"Speaking of money, we've found that G.S. keeps us competitive on costs in the broadest sense. They have the equipment, and the experience, to do precision jobs like ours on a production basis—we aren't paying on the "hand-made" scale. Besides, they make *all* the kinds of Gears and Gearing we need—Spurs, Spirals, Bevels, Helicals, Internals, Zerols, Clusters, Ratchets, Splines, Hobbing, Worm Gearing. That simplifies our specifying and buying—and that's worth money, too.

"Just one more thing. When we do have a special or unusual problem about Gearing, either in production or in development of new projects, we've found that G.S. is as close as our phone. We've had their experts in from their factory several times, and their broad, practical experience has been mighty helpful. It's like having extra specialists right on our own staff!

"Yes, *we* depend on G.S. for our Precision Gearing. Why don't *you* talk to them about your Gear problems?"

YOU'LL FIND G.S. GEARING IN TOP QUALITY PRODUCTS LIKE THESE . . .

Adding Machines • Aircraft Carburetors & Fuel Metering Systems • Aircraft Instruments and Radios • Automatic Musical Instruments • Automation Systems • Business Machines • Check Signing & Protecting Machines • Clippers for Barbers, Animal Shearing & Hedge Trimming • Cloth Cutting Machines • Coin Changers & Counters • Communication Equipment • Control Mechanisms • Electric Fans • Electric Motors • Floor Polishers, Sanders, Scrubbers, Sweepers • Food & Drink Mixers, Blenders • Home Appliances • Lawn Sprinklers • Machine Tools • Meat Tenderizers, Grinders, Slicers • Military Equipment • Motion Picture Cameras & Projectors • Optical Instruments • Outboard Motors • Pneumatic Production Tools • Radio & Radar Tuning Assemblies • Radio Anti-backlash Gears • Range Finders • Record Changers • Sewing Machines • Steel Strap Stretchers • Step Switches • Tapping, Drilling & Threading Equipment • Telephone Dials • Television Sets • Thermostatic Controls • Typewriters • Vending Machines • Washing Machines.

SEND FOR G.S. *illustrated folder! See where and how we mass-manufacture Small Gearing to uniformly fine tolerances. Folder contains 23 pictures of Small Gears, plant view, as well as Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!*

44 Years of Specializing in Small Gearing!

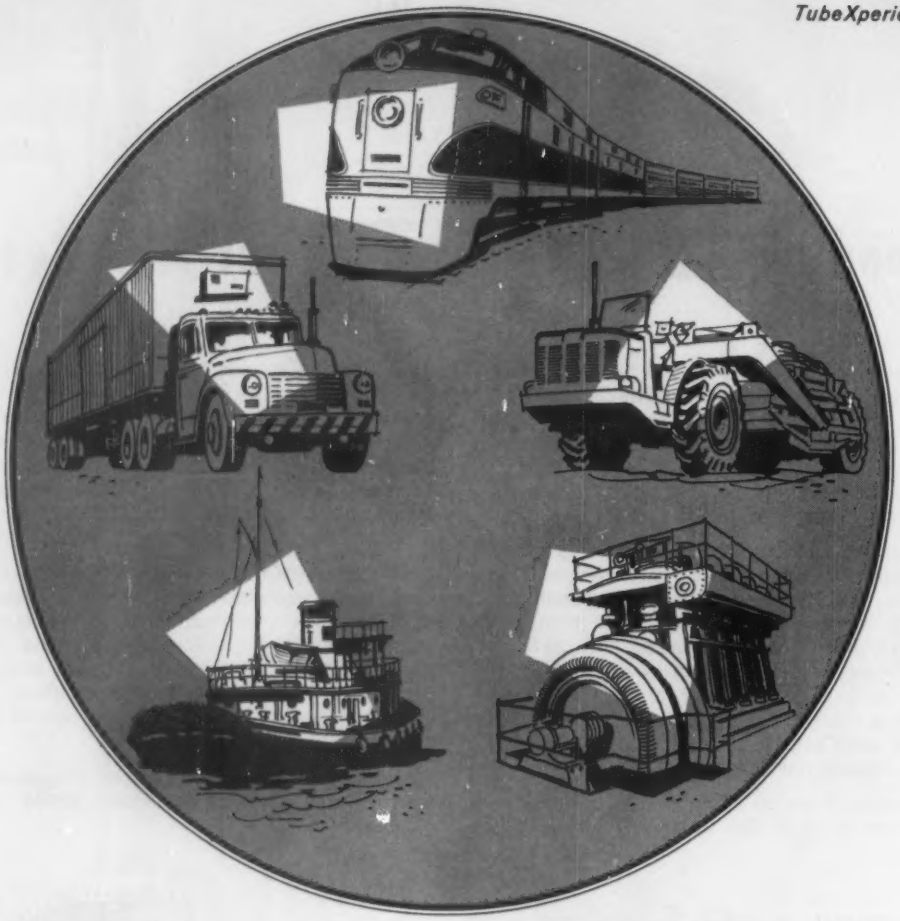
FRACTIONAL HORSEPOWER GEARING

GEAR Specialties, Inc.

2635 WEST MEDILL AVENUE
CHICAGO 47, ILLINOIS

SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARING



Feedlines for hungry horsepower . . . diesel fuel injection tubing by Superior

Fuel injection systems are the heart of thousands of diesel-powered trucks, locomotives, roadbuilding equipment, electric generators, and marine power plants. The tubing that conveys the fuel from injection pump to nozzle assembly is an important component. It must resist the stresses of pressure and vibration, yet be ductile enough to be cold swaged and upset and be cold formed into loops and bends without excessive springback. It must have a clean ID, tremendous burst strength, and high fatigue resistance. Superior diesel fuel injection tubing is just such a premium product.

Type C-1008 and Type MT-1010 carbon steel tubing are most commonly specified for this application, but alloy and stainless steel tubing for pressures above 9000 psi and greater corrosion resistance is available. Superior also makes tubing for many other applications—supplies both general and special purpose tubing for aircraft, missiles, electrical, electronic, chemical, hydraulic, dairy and nuclear, to name a few. For complete information, write Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

SOME REASONS WHY SUPERIOR FUEL INJECTION TUBING IS A PREMIUM PRODUCT

- It will handle pressures to 9000 psi, is hydrostatically tested to various pressures according to specification
- It is cold drawn, dead soft annealed, and seamless
- It is ID conditioned to remove fissures and other defects
- It is free from ID radial cracks deeper than .005 in. or 5% of wall thickness, whichever is less
- It is annealed at finish in controlled atmosphere furnaces to produce a soft, ductile and scalefree material
- Fracture tests are performed when requested

Superior Tube

The big name in small tubing

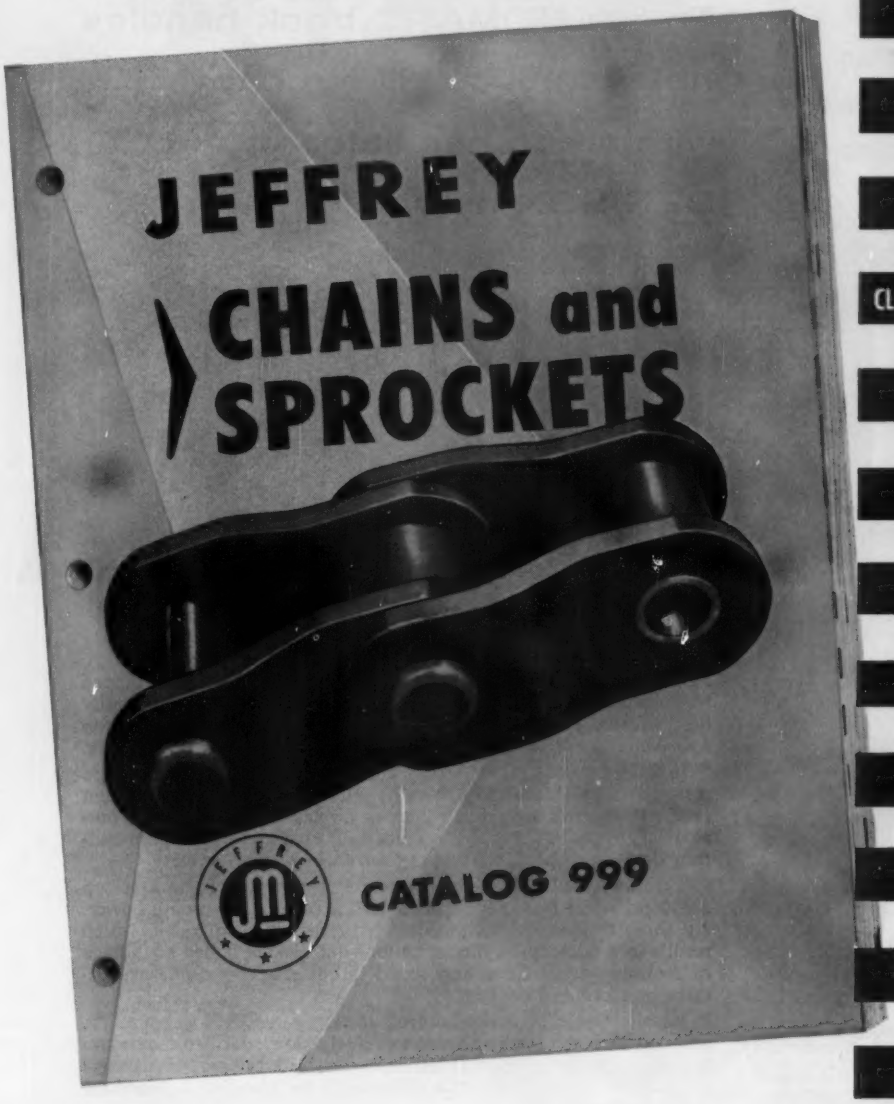
NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

CHAINS FOR EVERY SERVICE

described and illustrated (indexed as shown) in this new catalog to make specifying easier



- CHAIN DATA
- DETACHABLE LINK
- CLASS 400 PINTLE
- TYPE H MILL
- CLASS 700 PINTLE
- CLASS 800 STEEL BUSHED
- MALLEABLE ROLLER
- DRAG OR REFUSE
- COMBINATION
- BARLOOP
- RIVETLESS
- STEEL KNUCKLE
- STEEL THIMBLE ROLLER
  DRIVE AND CONVEYOR TYPES
- STEEL BLOCK
- ASA FINISHED ROLLER
  CHAINS AND SPROCKETS
- SPROCKET WHEELS

MEN WHO SELECT CHAIN for power transmission and conveying applications will find this new Jeffrey catalog extremely helpful. It recommends types of chains and sprockets for various applications, simplifying selection of the best and most economical for each job. Jeffrey has the experience in designing and engineering to help you in any specific job—conveying, elevating or transmission drive application. For service on your chain requirements, call your nearest Jeffrey sales office or Jeffrey distributor.

For a copy of Catalog 999, write The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT...TRANSMISSION MACHINERY...CONTRACT MANUFACTURING

Circle 449 on Page 19

Denison and Denison HydrOILics are registered trademarks of Denison Eng. Div., ABSCO

DENISON HydrOILics

This AUTOMATIC® truck handles hefty steel coil like a baby with smoother, safer DENISON hydraulic power

FLUID POWER

HYDRAULIC HANDLING *for steel coil. This "Skylift Giant" unit was developed by Automatic Transportation Co., Chicago—Division of Yale & Towne Mfg. Co. The "Coil Up-Ending Attachment" is powered by Denison Axial Piston hydraulic pumps.*

FLUID POWER for this "Skylift Giant" industrial truck—equipped with a special "Coil Up-Ending Attachment"—means it can easily heft rolls of coiled steel weighing from 10 to 40 tons. *Denison hydraulic power pays off here in smoother, faster, safer handling.*

In leading mills, these heavy-duty trucks speed handling and storage without damaging coils. The Coil Up-Ending Attachment enters the coil's inside diameter with a fixed ram . . . while the outside is gripped by a powerful hydraulic clamp. This clamp-and-ram design prevents "telescoping" of coils during handling.

Three hydraulic cylinders—powered by motor-driven Denison 3,000 psi Axial Piston Pumps—furnish lifting and clamping power. All three cylinders are connected hydraulically in parallel, which results in a telescopic-cylinder action—but has the added advantage of retaining equal force and speed throughout the stroke at constant pressure and delivery.

Result: Operator easily controls lowering speed at any level . . . and can inch the load up from extremely slow speed to maximum for which the flow control is set. *Safe, fast, smooth hydraulic control helps keep "Skylift" trucks continuously on-the-job . . . handling extra payloads.*

Here's the kind of job your Denison Hydraulic Specialist can help *you* do *now*. Call him in. See how Denison hydraulic power can help put *more payload into your equipment.*

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 Dublin Road • Columbus 16, Ohio

HYDRAULIC PRESSES
PUMPS • MOTORS • CONTROLS

DENISON
HYDRAULIC POWER

Circle 450 on Page 19

WEAR RESISTANT

THOMSON

60 Case

AVOID the HIGH COST and difficulty of fabricating long, hard & straight parts by conventional methods!

hardened and ground

SHAFTS, ROLLS, GUIDE RODS and other long-round parts

ELIMINATE WEAR and REDUCE COST

60 Case is the result of over 15 years of experimental work and production experience with hardened and ground shafts which are a requirement for BALL BUSHINGS, the Linear Ball Bearing manufactured by Thomson Industries, Inc.

The special techniques and equipment that have been developed enable high production rates and low handling costs. This permits big savings over conventional methods which are plagued with erratic warpage, straightening and resultant grinding problems. Finished *60 Case* parts frequently cost less than the scrap losses that result from conventional methods.

60 Case material has a surface hardness close to 60 on the Rockwell C scale which is essential to resist wear.

Long lengths of material ranging in diameter from ¼" to 4" are stocked to enable prompt shipment of *60 Case* parts, with or without special machining. *Write for literature and name of your local representative.*

For emergency needs call collect
MAnhasset 7-1800

ADVANTAGES of *60 Case*

- COST REDUCTION
- HARD BEARING SURFACE
- NICK-& DENT-PROOF
- ACCURATE DIAMETERS
- GROUND FINISH
- STRAIGHT PARTS
- DELIVERY FROM STOCK
- ADDED STRENGTH
- UNIFORM HIGH QUALITY

TYPICAL *60 Case* PARTS

GUIDE RODS • SHAFTING • ROLLS • TRAVERSE RAILS
PISTON RODS • ARBORS • LEADER PINS • TIE RODS
KING PINS • AXLES • CONTROL RODS • GUIDE POSTS
MANDRELS • BEARING ROLLERS • SPINDLES

THOMSON INDUSTRIES Inc.

Dept. C-5, Manhasset, New York

Circle 451 on Page 19

PARTS HARDENED to 60 C...
increase life...reduce cost!

These are no sissies!

They are AE Hydramite® pumps, the heavy-duty hydraulic pumps that start delivering where other "heavy-duty" pumps leave off. Check into them for the tough jobs where you want sheer stamina...the jobs where extra reliability and sustained performance are an urgent requirement.

To meet your specific requirements, Hydramite pumps can be supplied for constant displacement from 3 to 25 gpm at 5,000 psi and 60 to 100 gpm at 3,000 psi for hydraulic fluids with viscosities of 150 to 300 ssu at 100°F. In special applications they have handled viscosities as low as 40 and as high as 900 ssu at 100°F. Special materials and seals permit handling of missile fuels and special fluids at higher temperatures. Available in flange, foot or face mounted styles.

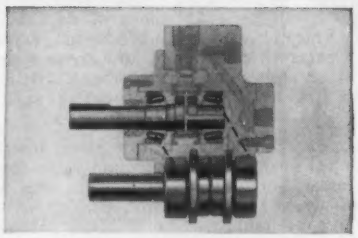
Write or call American Engineering Company, Dept. P-147, Philadelphia 37, Pa. Phone: CUmberland 9-3800.

See our four-page catalog in Sweet's Product Design File, or write us for reprint (Catalog P-60).

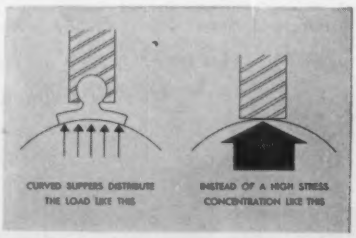
AMERICAN ENGINEERING COMPANY

Division of United Industrial Corporation

Hele-Shaw® Pumps, Lo-Hed Hoists, AE Marine Deck Auxiliaries, Vibra-Grate, Perfect Spread and Taylor Stokers.



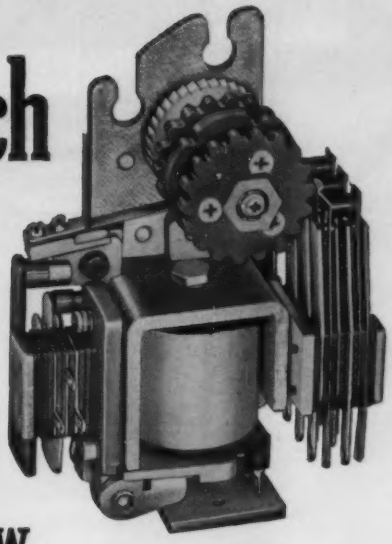
Tapered roller bearings. High-capacity, heavy-duty tapered roller bearings support the eccentric cam shaft. This means that a Hydramite can take more punishment . . . handle heavier unbalanced loads . . . and last longer.



Curved Slipper distributes thrust load of the plungers and reduces unit stress to the point where maintenance is never required at what is a critical wear spot in most hydraulic pumps.

Circle 452 on Page 19

Here's a Memory Switch You Won't Forget...



the New CLARE CAM-OPERATED type 200

offers a program control unit in reduced space and with simpler wiring. Actuating cams can be cut with a sequence of notches and lobes programmed to meet the contact switching desired. In addition, the Type 200 acts as a memory switch of unusual dependability and long life.

Operating life is measured in millions of steps. Over 30,000,000 operations have been logged with two cams and a 36-tooth ratchet; 10,000,000 with eight cams. Models are available with from 1 to 8 cams. Operating speed is 60 sps, self-interrupted, 30 sps, remote-impulsed.

The Type 200, as are all CLARE stepping switches, is available with a wide variety of hermetically sealed enclosures or dust covers to insure precise operation under all conditions.

Production quantities available in late fall. Send for Bulletin CPC-7

C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., P. O. Box 134, Downsview, Ontario. Cable Address: CLARELAY

A FULL LINE OF CLARE STEPPING SWITCHES WITH MANY IMPROVED FEATURES

TYPE 210
Has 10 points, with as many as 120 contacts in twelve 10-point levels or four 30-point levels.

TYPE 211
Offers up to 132 contact points on twelve 11-point levels or four 33-point levels.

TYPE 20
Up to 480 contact points in twelve 40-point levels or 320 in sixteen 20-point levels.

TYPE 26
Up to 624 contact points in twelve 52-point levels or 416 in sixteen 26-point levels.

DIRECT DRIVE
Up to three 10-point levels, plus an off position.

new!

Most complete Stepping Switch Catalog ever offered!

Complete data on construction features, circuitry, performance characteristics and application advantages of the entire CLARE line.

SEND FOR CATALOG 202 TODAY

CLARE

Relays and Related Control Components

For Catalog 202 Circle 453 on page 19 ▲

For Bulletin CPC-7 Circle 454 on page 19 ▲

PEM FIRST NAME IN

Slots (or corrugations) prevent Fastener from turning.
Sheet remains flush on opposite side. No swaged rim projects.
Clinching ring squeezes sheet material around back-tapered shank, securely locking Fastener

THE

original

SELF-CLINCHING FASTENER

Fifteen years ago Penn Engineering and Manufacturing Company introduced the self-clinching fastener, providing load-bearing threads in a wide range of—steel, aluminum, brass and copper sheets, "too thin to thread."

THE ANSWER TO PRODUCTION FASTENING—This unique, exclusive design was immediately recognized as the answer to production fastening by leading manufacturers of aircraft and missiles, automotive, electronic and communication equipment, business machines, farm machinery, electrical appliances, transportation equipment, vending machines, home appliances, etc. Stimulated the cost-conscious sheet metal assembly techniques utilized, today, by many of these manufacturers.

INSTALLED BY A SQUEEZE with the greatest of ease (without special tools) Users tell us that—because the shank of PEM nuts acts as their own pilot . . . because, being round, they require no indexing . . . because they require no special tools . . . because several may be pressed into place in a single operation . . .

THEY SAVE THEIR COST MANY TIMES OVER . . . in time, labor and special equipment. PEM nuts are one of the most profitable items in the assembly line.

Today, PEM Self-Clinching Nuts are made in six types for sheet thicknesses from .030" and up—in steel (with various rust resistant finishes), stainless steel, monel and aluminum. Sizes range from #2 to ¼". Also made as Blind Fasteners for pressure seal applications.

For complete information, write on your letterhead for Bulletin No. CL359 and sample.

Circle 455 on Page 19

Engineered projections. No burnouts in thin sheets.
Round body—no indexing. Compact. Fits on narrow flanges.
Self-locating pilot. Simplified electrodes.
Shank protects threads from weld spatter. No retapping.

specify

PEM WELD FASTENERS of Steel or Stainless Steel

PEM Weld Fasteners are designed for production . . . Faster Assembly . . . Lower Equipment and Labor Costs . . . and corrosion resistance, too, when required.

SHANK locates and protects threads against weld splatter . . . eliminates retapping.

ENGINEERED PROJECTIONS prevent burnouts in thin sheets.

SIMPLE ELECTRODES . . . no pilots required.

ROUND COMPACT SHAPE . . . no indexing in assembly . . . fit on narrow flanges.

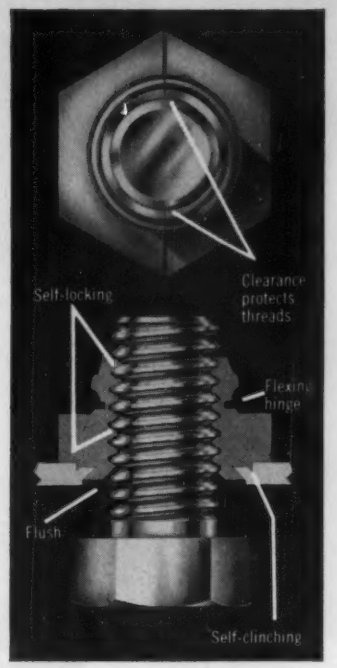
Write on your letterhead for Bulletin WN-1158 and sample for trial.

Circle 456 on Page 19

PENN ENGINEERING & MANUFACTURING

New York (Belle Harbor, L.I.)—Neptune 4-7103 Chicago (Forest Park, Ill.)—Forest 6-4971 Detroit—University 3-5189

CAPTIVE FASTENERS



ALL-METAL SELF-LOCKING SELF-CLINCHING PEM NUTS

are tops in performance

Combine two essential functions in one lightweight, low-cost unit.

The self-clinching feature is the same tried and proven original PEM design, recognized by industry as the answer to production fastening. It is installed by a squeeze into sheet metal, too thin to thread, by standard pneumatic, hydraulic or mechanical presses.

The all-metal, self-locking feature offers distinct lock-nut design improvements required for top performance under temperature, vibration and stress requirements of such high-reliability services as missile, rocket, aircraft and electronic components.

Exclusive Design • Outstanding Advantages: The All-Metal, Self-Locking features of the new PEM Nut speak for themselves:

ONE SLOT design: two rugged semi-circular jaws with inherent flexing action—far stronger than several less-supported segments.

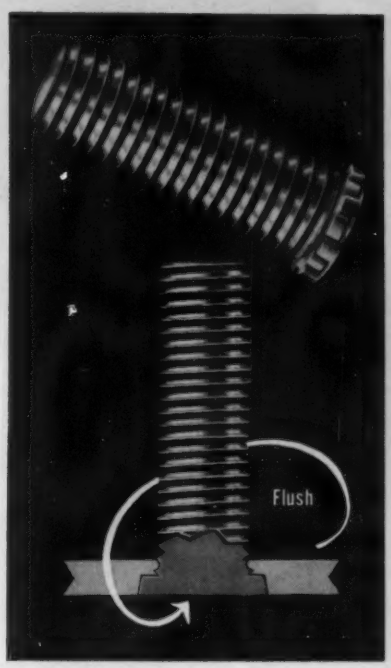
FLEXING HINGE: a machined slot at the base of each semi-circular jaw retains inherent flexing action, permanently. Guarantees against relaxation and loosening in severe service. Permits reuse, repeatedly, without diminishing self-locking efficiency.

PROTECTS THREADS: fewer segments—plus relief of cutting edges of single slot design, to provide clearance, insures that *no* cutting edges come in contact with the screw.

Made in #303 stainless steel (temperatures to 800° F); steel (temperatures to 500° F); high strength aluminum alloy (temperatures to 250° F); in sizes from #4-40 to #10-32 for use in aluminum, brass, copper, and cold-rolled steel sheets of thicknesses from .040 up and stainless steel sheets from .050 up.

Write on your letterhead for literature and sample for test.

Circle 457 on Page 19



now PEM SELF-CLINCHING CAPTIVE STUDS

"installed by a squeeze with the greatest of ease"

Answering Industry's demand for a captive stud employing the same unique design as the line of PEM captive Self-Clinching Nuts—which ushered in production fastening in sheet metal assembly—Penn Engineering and Manufacturing Corp. has produced the PEM flush-head self-clinching stud.

Saving time, labor, weight on tough assembly jobs, these studs make a surprisingly simple operation out of what formerly was accomplished by various slow and costly makeshift assembly methods, such as welding.

You simply place the studs—one or several at a time—into drilled or punched holes in the panel and squeeze them into place with any standard pneumatic or oil-hydraulic squeezer or mechanical press.

The squeezing action embeds the head projections into the sheet—the displaced metal flowing smoothly and evenly around the back-tapered shank and annular groove to securely lock the stud into the panel with high torque and pushout resistance.

Try them. Write on your letterhead for literature and sample. Sizes from #4-40 to 5/16-18. Carbon steel or #305 stainless steel, for use in various aluminum alloys, brass, copper, cold rolled steel and similar sheets in thicknesses from .040 up.

Circle 458 on Page 19

PEM

CORPORATION, DOYLESTOWN, PENNSYLVANIA

Los Angeles—Bradshaw 2-8097
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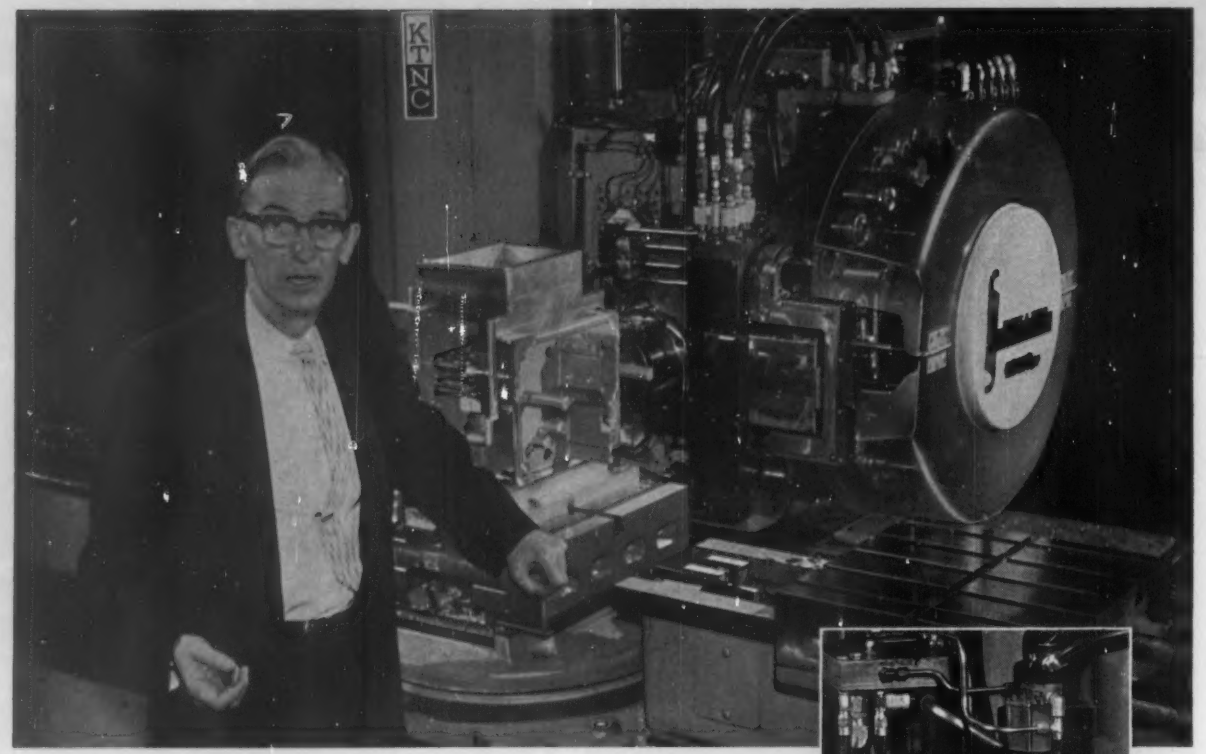


Mr. Julian Kerlin, Field Service Engineer for Kearney-Trecker Service Division, explains the contribution of Micro-Fog Lubrication to MILWAUKEE-MATIC reliability and ease of servicing.

Norgren Micro-Fog® Lubrication gives Kearney & Trecker greater flexibility in machine design

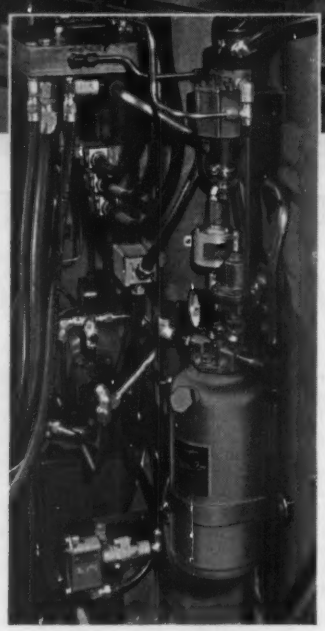
The new Kearney & Trecker tape-controlled MILWAUKEE-MATIC is an outstanding example of flexibility in modern machine design. In a single machine, the MILWAUKEE-MATIC performs all the operations of milling, drilling, reaming, tapping and boring that usually require several machines.

The Milwaukee-Matic is designed for maximum "chip time" and minimum set up and down time. This requires high reliability of operation and provision for rapid servicing.

This is why Kearney & Trecker engineers chose **Norgren** Micro-Fog for the lubrication system.

The Micro-Fog centralized air-borne lubrication system gives constant, reliable, metered lubrication at each bearing point. Alarm devices are connected to the control system of the machine to give warning of conditions affecting proper lubrication.

Micro-Fog is conducted to all bearing points through tubing, eliminating the need for cumbersome and costly return piping, oil filters, sumps and pumps. The result, as Kearney & Trecker found, is a wider latitude in machine design. With **Norgren** Micro-Fog, they were able to make maximum use of unitized construction in the MILWAUKEE-MATIC, providing for fast disassembly and component replacement.



This Norgren Micro-fog Lubro-Control Unit provides lubrication for the bearings on Kearney-Trecker's MILWAUKEE-MATIC, and for the slides, ways, gears and clutches in the head.

If you design machine tools which require measured, reliable lubrication of bearings, gears, slides, chains or ways, and want greater design flexibility, it will pay you to investigate Norgren Micro-Fog Lubrication. Write for detailed information, or call your nearby Norgren Representative listed in your telephone directory.

FOUNDED IN 1926

C.A. NORGREN CO.

3442 SOUTH ELATI STREET
ENGLEWOOD, COLORADO

Circle 459 on Page 19

"Will the weld be as strong as the cylinder?"

Marion Power Shovel asked this question when we recommended two-piece forgings (at considerable savings over the former one-piece forgings) for use as jack cylinders in their giant electric shovels. We answered "yes" . . . and tests show the weld metal has higher mechanical properties than the minimum physicals required for the cylinder.

BECAUSE THE HOLE *at the cylinder end is small, machining the sleeve before the head is welded on is lots easier and faster than machining the former one-piece forging. There's more room to work; the tool can get a good grip on the piece, hog out the metal, instead of pick it out. The savings are more than enough to offset the added welding cost.*

FOUR FORGED-AND-WELDED *"equalizing" cylinders, like those above, are used to keep the upper frame of this Type 5761 Electric Shovel level during operation. Made by Marion Power Shovel, Marion, Ohio, this shovel's dipper has a 65 cu yd capacity.*

Forged from manganese-vanadium steel, this sleeve-and-head cylinder weighs 22,690 lb.

The sleeve itself is 9 ft, 10 in. long, with a body OD of 45 in. Flange OD is 48 in.; flange ID, 35¼ in. The wall is 5-in. thick. To produce it, we upset, punch, hollow-forge, double-normalize and temper. Then we finish-machine to size, including the weld bevel on the end of the sleeve.

We forge the head as a disc of 49 in. diameter, and 11-in. long. Then we finish-machine it to size (45-in. OD, 9¾-in. long), including the weld bevel, and treat it the same as the sleeve.

The two pieces are then assembled and welded. The cylinder receives a stress-relief anneal after welding, and the weld is radiographed to assure soundness. Excess weld on the OD and ID is then machined off.

If you have a forgings problem, Bethlehem is a good company to get in touch with. We think as hard about one-pound drop forgings, as we do about 200-ton press forgings. To start us thinking about your forging, call the Bethlehem sales office nearest you.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

Steel
For strength
. . . economy
. . . versatility

BETHLEHEM STEEL

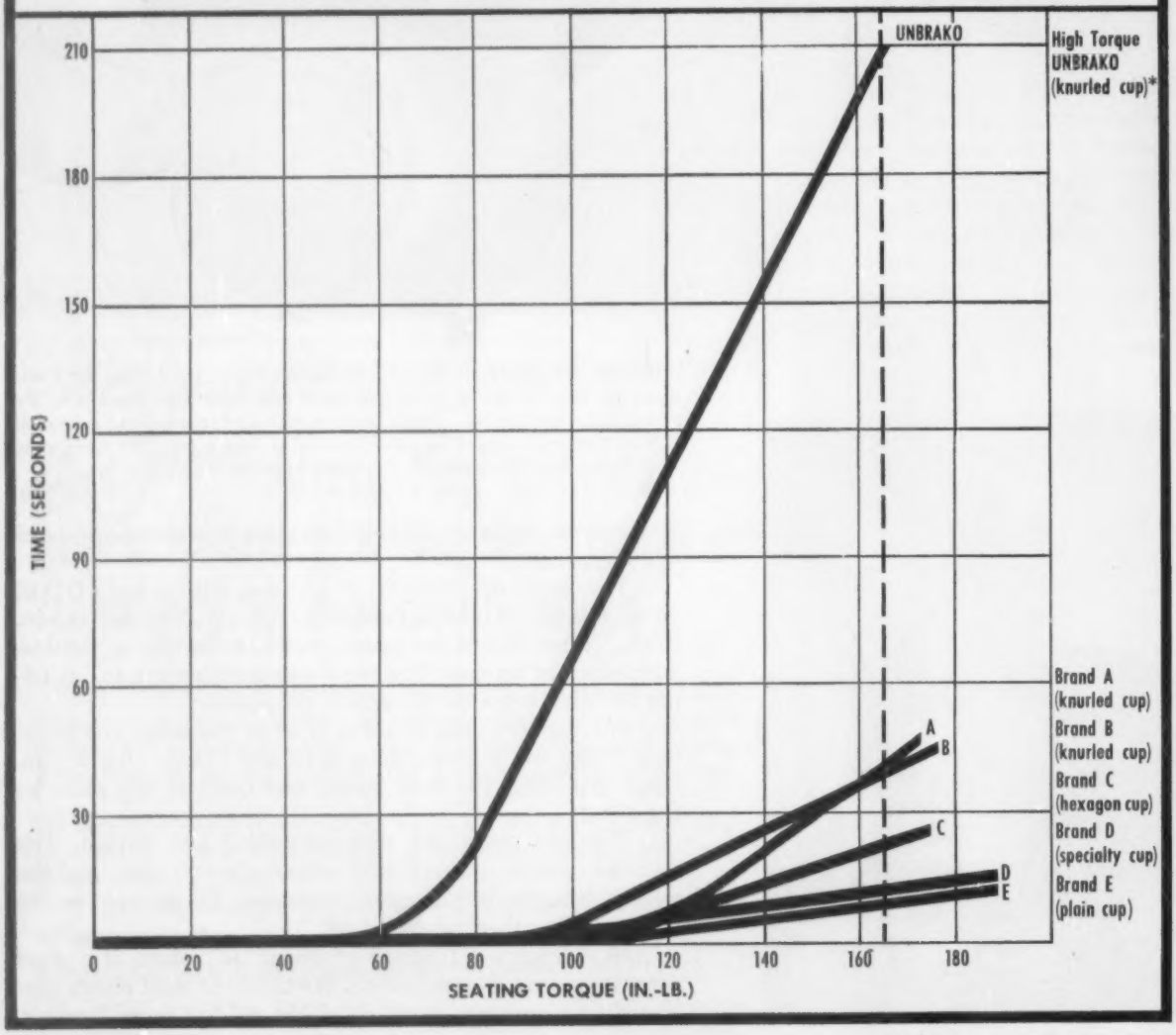
BETHLEHEM STEEL

Circle 460 on Page 19

What else is there to say?

HOLDING POWER UNDER IMPACT-INDUCED VIBRATION

$^5/_{16}$-18 x $^5/_{16}$ Socket Set Screws (1750 cycles per minute)



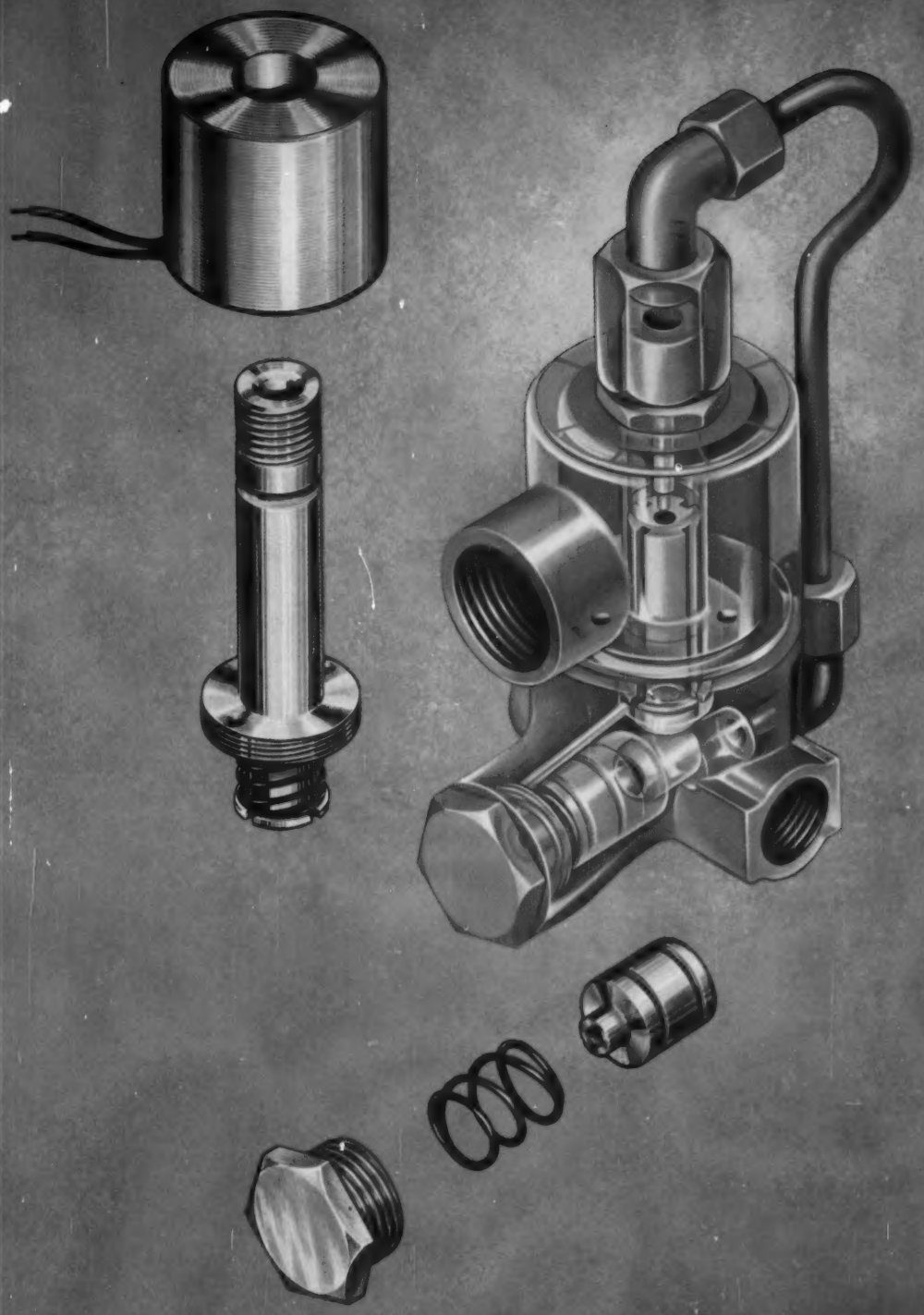
*Standard . . . and at no extra cost! For size range and price information, contact your local UNBRAKO distributor or write Standard Pressed Steel Co., Industrial Fastener Division, SPS, Jenkintown 18, Pa.

sps

where reliability replaces probability

Circle 461 on Page 19

Circle 462 on Page 19→

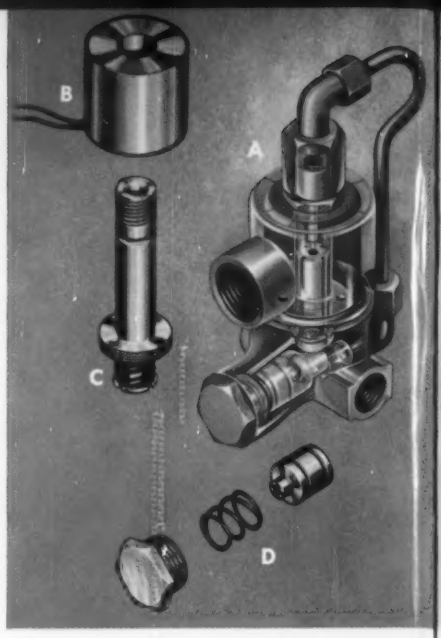


SKINNER 2-way Solenoid Valves

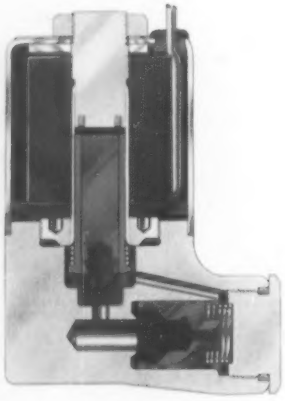
for high flow, high pressure applications

Here's how Skinner two-way valve design provides long lasting, trouble-free operation

- **Underwriters' Laboratories approved**
- **Stainless steel internal parts resist corrosion**
- **Forged naval brass body**
- **Famous Skinner V5 solenoid operator**
- **Well rounded main orifice and pilot seats**



A—Transparent view of normally open 2-way R type valve with piped pilot exhaust return
B—Coil C—Sleeve, plunger and spring assembly
D—Piston assembly with soft synthetic insert



NORMALLY CLOSED TYPE R2

When you have high-flow control problems at standard or high pressures the new Skinner two-way R series valves may be the answer. These pilot-operated solenoid valves are designed for use with air, oil, water, inert gases and other common media at operating pressure differentials of 5 up to 1250 PSI. They may be used for all types of control applications, such as: in high-pressure lifting, commercial laundry equipment, machinery, machine tooling, spraying, etc.

Skinner R series two-way valves have forged naval brass bodies to provide a dense metal structure and use a foolproof stainless steel piston with soft synthetic insert to open and seal the main orifice. Types are available normally open or normally closed, in standard and explosion-proof construction.

To make installation easy for every application, a wide choice of electrical housing options is available. These include JIC, AN connector, automotive terminals, etc. All housings can be rotated 360°. Manual override is also offered to permit manual opening of normally closed valves, or closing of normally open valves, in emergency.

Skinner R series valves may be used with all common voltages and frequencies and there are several coil types such as: varnished, molded waterproof, tropicalized and high temperature for specific applications.

The R series, illustrated here, is just one in a complete range of 2-, 3- and 4-way Skinner solenoid valves.

TWO-WAY R SERIES SPECIFICATIONS

Types	R2 XR2	R2H XR2H	R2H6	RP1 XRP1
Position	Normally closed	Normally closed	Normally closed	Normally open
Pipe Size (NPTF Dry Seal)	¼"	¼"	¼"	¼"
Orifice Size	¼"	¼"	¼"	¼"
Cv Factor	.758	.758	.758	.758
Operating Pressure Differential (PSI) Minimum	5	5	5	5
Maximum AC Service	200	1250	—	150
Maximum DC Service	200	500	1000	150
Leakage	Bubbletight	Bubbletight	Bubbletight	Bubbletight
Temperature Range (Ambient and Media)	Minus 40°F to plus 180°F	Minus 40°F to plus 180°F	Minus 40°F to plus 180°F	Minus 40°F to plus 180°F

When you specify solenoid valves, specify Skinner. Skinner solenoid valves are distributed nationally.

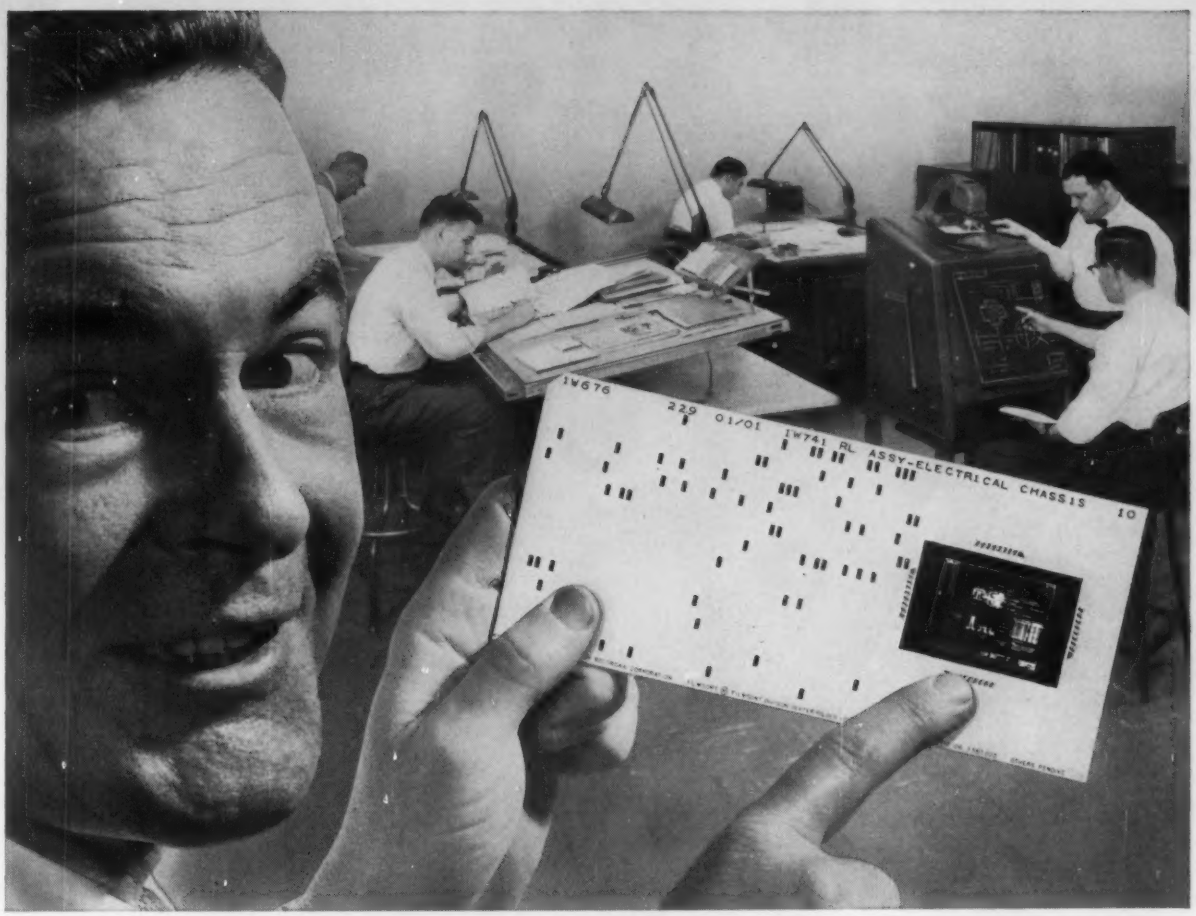
For complete information, contact a Skinner Distributor listed in the Yellow Pages or write us at the address below.

SKINNER ELECTRIC VALVES

THE CREST OF QUALITY

SKINNER ELECTRIC VALVE DIVISION,
THE SKINNER CHUCK COMPANY • NEW BRITAIN, CONNECTICUT, U.S.A.

PRINTED IN U.S.A.



Why it's all-important to get good microfilm pictures!

Your success with an automated drawing file depends mainly on the quality of your microfilm reproductions.

They must be completely legible when checked in film readers . . . they must also produce accurate, easy-to-read paper prints and duplicate microfilms.

Here's where Recordak techniques and quality controls, developed over years of research, pay rich dividends for drafting rooms large and small. They provide remarkably sharp and uniform pictures on low-cost 35mm microfilm which *more than meet DOD requirements* (120 lines per mm resolution at 30 to 1 reduction ratio).

Mounting these superb Recordak microfilm frames in aperture cards gives you an active drawing file which can be kept at the finger tips . . . always available for easy viewing in a Recordak film reader.

And when paper prints are needed, reduced-size prints can be made fast—directly from the "microfilm" card—by low-cost photographic, xerographic or electrostatic methods. Duplicate cards can also be made for branches, vendors, government agencies for pennies apiece.

Send for free booklet giving additional details on this precision system available through Recordak and its nation-wide dealer organization.

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Gentlemen: Send free booklet describing RECORDAK Engineering Drawing System. No obligation whatsoever.

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RECORDAK®

(Subsidiary of Eastman Kodak Company)

originator of modern microfilming

—now in its 33rd year

IN CANADA contact Recordak of Canada Ltd., Toronto

←Circle 462 on Page 19

Circle 463 on Page 19

tops in efficiency— and a cinch to change

HERE'S ALL YOU DO! Unscrew the two fittings that join the Purolator GF-11 Filter to the fuel line. Throw away the dirty filter. Fasten in the replacement. Now you're ready for 5,000 miles of efficient, trouble-free fuel filtration. Total time involved? *Less than 5 minutes.*

MOTORS RUN SMOOTHER . . . Because this Micronic® filter removes dirt, metal, rust, scale and gum . . . even microscopic particles down to 5 microns.

ADAPTABLE TO ALL GASOLINE ENGINES. Purolator fuel filters like the GF-11 shown above, are standard equipment on most 1960 cars. However, it can be incorporated into the fuel system of almost *any* gasoline engine – automotive, portable or marine.

MORE ADVANTAGES. Easy installation and replacement is a big reason for the popularity of the Purolator GF-11 Fuel Filter. But here are more:

•PEAK EFFICIENCY. Because Purolator replacement filters are inexpensive, and easily installed, chances are they'll be replaced at proper intervals – *and always work at peak efficiency.*

•LONGER SERVICE LIFE. Because of the special pleated construction of the filtering unit, the GF-11 has fully *70 square inches* of filtering surface. It operates longer at peak efficiency.

•COMPACTNESS. The GF-11 measures about 3" by 1⅞". It can be installed either horizontally or vertically.

•VERSATILITY. The GF-11 Filter can be installed as an O. E. M. item on practically any gasoline-engine – from sport cars and garden tractors to power mowers and midget racers.

For complete information on the GF-11 and other Purolator filters, write to Purolator Products, Inc., Department 3849, Rahway, New Jersey.

Filtration for Every Known Fluid

PUROLATOR

PRODUCTS, INC.

Rahway, New Jersey, and Toronto, Ontario, Canada

BARBER-GREENE specifies INTERNATIONAL Power

for world's leading line of asphalt plants!

Report from Guy Banister,
Chief Technical Engineer,
Barber-Greene Co., Aurora, Ill.

"We standardized on International diesels for Barber-Greene Continuous Mix Asphalt Plants in 1947, and owners' reports prove we made an excellent choice."

"For 30 years Barber-Greene Continuous Plants have played a major role in making asphalt paving the world's most used road surface. Since the 30's road builders have been able to produce a controlled high-quality mix in high volume at low cost, and that calls for *efficient power.*

"Because the whole paving operation depends on our plants for asphalt production, plant downtime can run as high as $5,000 hourly. And since engines on the plants operate under continuous load 8 to 10 hours daily—that calls for *dependable power.*

"Since Barber-Greene Continuous Mix Plants are highly mobile—often moving to 6 or 8 jobs in a season—that calls for engines supported by an *excellent parts and service organization.*

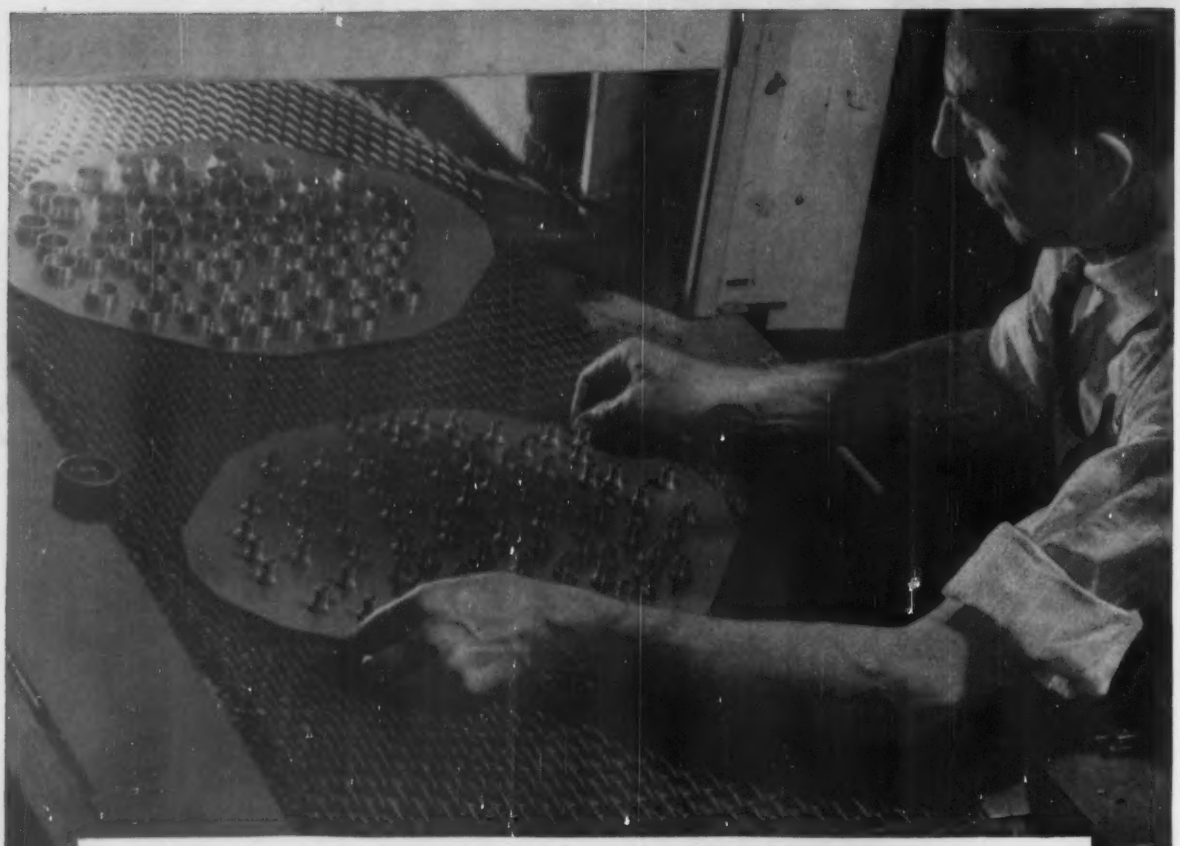
"International diesel engines meet Barber-Greene standards for efficiency, dependability, and parts and service support. That's why we standardized on IH power for these plants. Performance records over the past 13 years show that our customers, too, are satisfied International users."

You, too, can build into your products the advantages of International power. Check the complete International engine line—35 carbureted and diesel models from 16.8 to 385 max. hp. You'll like the one common feature of all 35 engines: fastest payback power for users. Just call or write International Harvester Co., Engine Sales Department, Construction Equipment Division, Melrose Park, Ill.

INTERNATIONAL®
IH ENGINES

International Harvester Co.,
180 North Michigan Ave.,
Chicago 1, Illinois
A COMPLETE POWER PACKAGE

Circle 465 on Page 19



. . . CONTINUOUS PROCESSING -- 1965 . . .

CAMBRIDGE METAL-MESH BELTS help you beat *today's* profit squeeze—give you the low-cost production and high product quality needed for the *competitive '60's!*

Combined movement and processing means metal parts, foods, ceramics or chemicals are processed faster, more uniformly—without costly manual handling. High product quality is maintained because heat, cold or liquids flow through the belt and around the product for thorough treatment. Cambridge Belts save on operating costs, too. Superior belt design and manufacturing techniques mean longer life, fewer repairs, lower operating costs. Belts can be made heatproof, coldproof or acidproof—in any mesh, weave, metal or alloy—with any side or surface attachments.

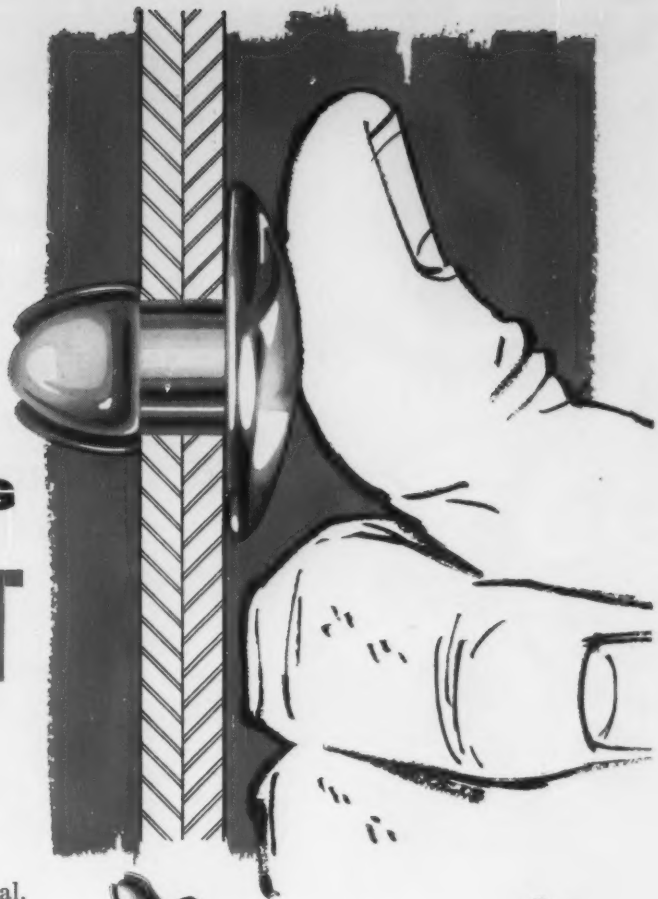
Whether you're designing machinery for your own use, or for resale, the Cambridge Field Engineer in your area will be glad to discuss the many advantages of Cambridge Belts—from the manufacturing end to installation and service. Call him today. He's listed in the yellow pages under "Belting, Mechanical". Or, write for FREE 130-PAGE REFERENCE MANUAL.

The Cambridge Wire Cloth Co.

DEPARTMENT N • CAMBRIDGE 8, MARYLAND

Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications

to fasten
panels
or parts . . .



LIGHT, STRONG

TRIMOUNT STUDS

Designed for rapid assembly of sheet-metal, plastic or composite structures, Dot Trimount studs are available in both permanent and removable types. They can be pushed into drilled, stamped or molded holes by finger-pressure alone yet they lock positively in place and resist constant vibration.

Studs can be designed in steel or brass with various flange configurations for clinch, clip or clamp attachment to flexible or rigid panels as well as for push-through assembly. Available in all standard finishes . . . with or without decorative caps.

Push Rivet Stud
Shoulder Type (Capped)

Push Rivet Stud
Tapered Type (Capped)

Push Rivet Stud
Shoulder Type (Not Capped)

Push Rivet Stud
Tapered Type (Not Capped)

Clinch Type Stud

Clip-on Stud

Trim Stud
Barrel Type

Trim Stud
Scissors Type

Panel Type Stud

Loop Type Stud

Panel Stud
Staple Type

Panel Stud
Hook-on Type

DESIGN ENGINEERING SERVICE

Designers, metallurgists and plastics specialists on Dot's engineering staff are equipped to work out optimum combinations of metal and plastics to suit your particular requirements.

► *For further details, write for Engineering Data Catalog, Section H*

MAKERS OF DOT® FASTENERS

CARR FASTENER COMPANY

Division of United-Carr Fastener Corporation, Cambridge 42, Mass.

Offices in: Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Kalamazoo, Los Angeles, Louisville, New York, Philadelphia, Syracuse

Wherever in the world your hydraulic machinery operates . . .

Shell Tellus Oil is there

Other outstanding Shell Industrial Lubricants available world-wide

Shell Rimula Oils—for heavy-duty diesel engines
Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives
Shell Alvania Grease—multi-purpose industrial grease
Shell Turbo Oils—for utility, industrial and marine turbines
Shell Dromus Oils—soluble cutting oils for high-production metalworking
Shell Macoma Oils—for extreme pressure industrial gear lubrication
Shell Voluta Oils—for high-speed quenching with maximum stability

Around the world, Shell Tellus Oil is available—under the same brand name and providing the same performance that your domestic customers rely upon.

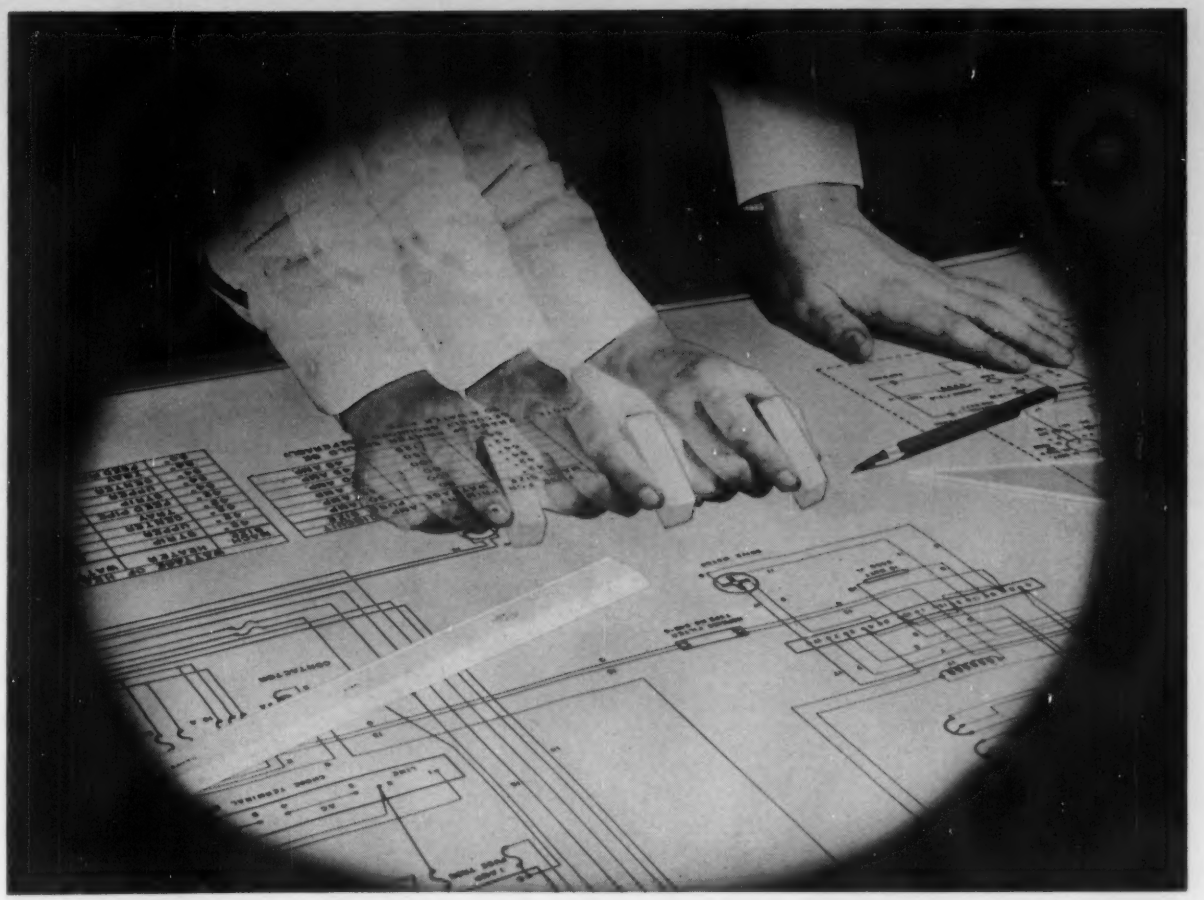
Tellus® Oil is top-rated as both a lubricant and control fluid for complex hydraulic systems. Its ability to combat oxidation, rust, sludge formation, wear and foaming has earned it world-wide popularity.

No matter where your hydraulic machinery is shipped, make Shell Tellus Oil your standard recommendation. Write for complete information.

AN INTERESTING FACT!
Every Shell Branded Industrial Lubricant is named for a sea shell. Shown here is the Cultellus costatus.

SHELL OIL COMPANY

50 WEST 50TH STREET.....NEW YORK 20, N. Y.
100 BUSH STREET.....SAN FRANCISCO 6, CALIFORNIA
IN CANADA: SHELL OIL COMPANY OF CANADA, LIMITED
505 UNIVERSITY AVENUE.....TORONTO 2, ONTARIO



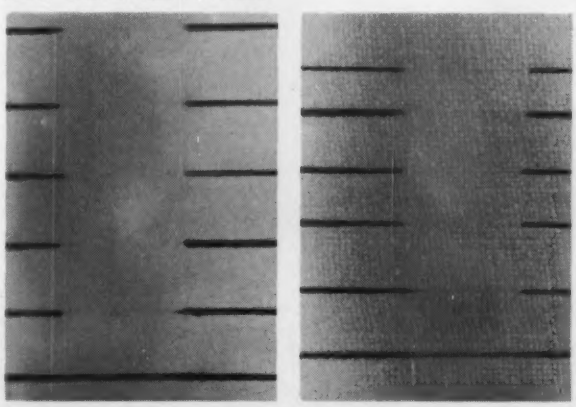
Make this erasure test and see for yourself why . . .

CRONAFLEX® HAS THE BEST DRAFTING SURFACE YOU CAN USE!

A good example of the consistent, balanced surface of CRONAFLEX is its superior *erasability*. CRONAFLEX not only erases easily and cleanly; it takes repeated erasing without ghosting or surface damage.

To prove it, make this simple test: draw a series of 6 lines horizontally on CRONAFLEX. Erase a vertical path through each line as you draw it, with a stroke long enough so that each succeeding line is drawn through another erasure. Now make the same test on the best grade of pencil cloth you have and compare the results. For more proof, reproduce each sample in a diazo machine and compare the prints.

Notice how cleanly and evenly CRONAFLEX (left) erases, without smudging or ghosting. Notice density and consistency of bottom line, drawn through 5 erasures! Compare same test made with good grade of pencil cloth (right). Bottom line drawn through erasure path is not uniform; erasures are uneven.



Superior covering power, cleanness of erasures and consistent line density—despite repeated erasing—are just a few of the reasons why CRONAFLEX gives you the best drafting surface you can use. For others, contact your local Du Pont Technical Representative or call your local Du Pont Photo Products Sales Office listed below. E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, Toronto.

DU PONT

REG. U. S. PAT. OFF.

Better Things for Better Living . . . *through Chemistry*

Atlanta 18, Ga., 1737 Ellsworth Dr. N. W.; Waltham 54, Mass., 45-4th Ave. (Boston,, Chicago 46, Ill., 4560 Touhy Ave., Edgebrook Sta., Cleveland 16, Ohio, 20575 Center Ridge Road; Dallas 7, Texas, 1628 Oak Lawn Ave.; Los Angeles 38, Calif 7051 Santa Monica Blvd.; New York 11, N. Y., 248 W. 18th St., Wynnewood, Pa. 308 E. Lancaster Ave. (Phila.). Export, Nemours Bldg. Wilmington 98, Del In Canada: Du Pont of Canada Limited Toronto

Circle 469 on Page 19

"Wait! I need it too!"

Everyone concerned with temperature control will want to read this new Fenwal Bulletin, "Smarter Looking — Smarter Acting Electronic Temperature Controllers and Indicators."

These modern transistorized instruments with thermistor sensors can be *more precisely matched* to requirements over a range from −50 to +600°F. Their many interchangeable, optional features let you order *exactly* what you need. And you can *combine* instruments . . . "build" to your specifications.

Here are just a few possibilities: single-point control . . . single-point control and indication . . . indication of up to ten controlled temperatures . . . ON-OFF or proportioning . . . indicating or non-indicating . . . set-point adjustment at instrument or remote . . . expanded scales for fine temperature adjustment . . . and many more. Ratings up to 10 amp/110 VAC. Each instrument is professionally styled to perfectly complement modern industrial machines or interiors. And, best of all, Fenwal design keeps costs *reasonable*.

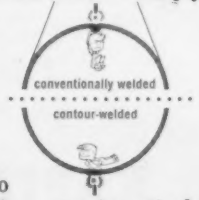
Get your copy of "Smarter Looking — Smarter Acting." Then get the *benefits* of this versatile new instrument family. Write FENWAL INCORPORATED, 199 Pleasant Street, Ashland, Mass.

Another example of how **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

"The Gravity Kid" shows how

CONTOUR-WELDED STAINLESS TUBING DEFIES CORROSIVE ATTACKS

It's smoother inside than any other tubing—welded or seamless—because the patented* Contour-welding process virtually eliminates the weld bead. And this smoother surface ensures greater resistance to corrosion—simply because there are fewer focal points for corrosive attack.



You see, in conventionally welded tubing, gravity pulls the molten metal down into the tubing. This forms a bead that is difficult to remove by cold working. And cold working can lead to undercuts that become focal areas for corrosive attack.

Contour-welded tubing, however, is welded at the bottom. Gravity still pulls the molten metal down. But now the weld area corresponds to the contour of the tube. There's virtually no weld bulge on the inside surface. And even on the O.D., the weld seam closely conforms to the tubing contour.

Contour-welded tubing is smoother, too, than seamless. That's because it's formed from uniformly rolled strip steel whereas seamless is extruded from a billet.

But get full details on this corrosion-resistant tubing. Send for our free 48-page manual on Contour-welded tubing in sizes from 1/8″ to 40″ O.D.—in stainless and high alloy steels, titanium, zirconium, zircalloy and Hastelloy.**

U.S. Patent 2,716,692

**Trademark Haynes Stellite Co.

TRENTWELD® Stainless and High Alloy Tubing

Trent Tube Company, a Subsidiary of Crucible Steel Company of America. General Offices and Mills: East Troy, Wisc.; Fullerton, Calif.

A real self-drilling screw!

P-K Tapits actually *drill* their way into light gage sheets when driven with a power driver! You eliminate hole drilling or punching with this newest idea in tapping screws from Parker-Kalon... speed sheet metal assemblies up to 50%

What's more, P-K Tapits have a serrated washer, integral with the head, that minimizes stripping, by acting as a built-in brake.

Production line tests with millions of P-K Tapits prove these advantages you get with no other screw:

Unique drill point—Tapits start drilling immediately! The cuneiform (pyramid-type) point prevents walking, skidding or creeping!

Uniform Hex Head—Same size hex head on the entire range of Tapits from #6 to #10 means you need only one size driver socket. Sharp corners, well-filled driving faces reduce socket wear.

Advanced washer design—the serrated washer scientifically distributes driving stresses . . . minimizes stripping.

Sharp-crested threads—Holes drilled by P-K Tapits are exactly root diameter. Tapits hold far better because thread in engagement material mates perfectly.

Properly hardened—P-K's exclusive laboratory-controlled hardening and tempering process results in a uniformly hardened screw with a tough core.

USE P-K'S MAGNETIC DRIVER SOCKET FOR POWER DRIVING!

You need only one size driver socket to drive any P-K Tapits! Get the P-K driver socket with a strong Alnico magnet that firmly holds the Tapits. Fits any ¼" driver with adjustable clutch. Socket can be refaced to extend life.

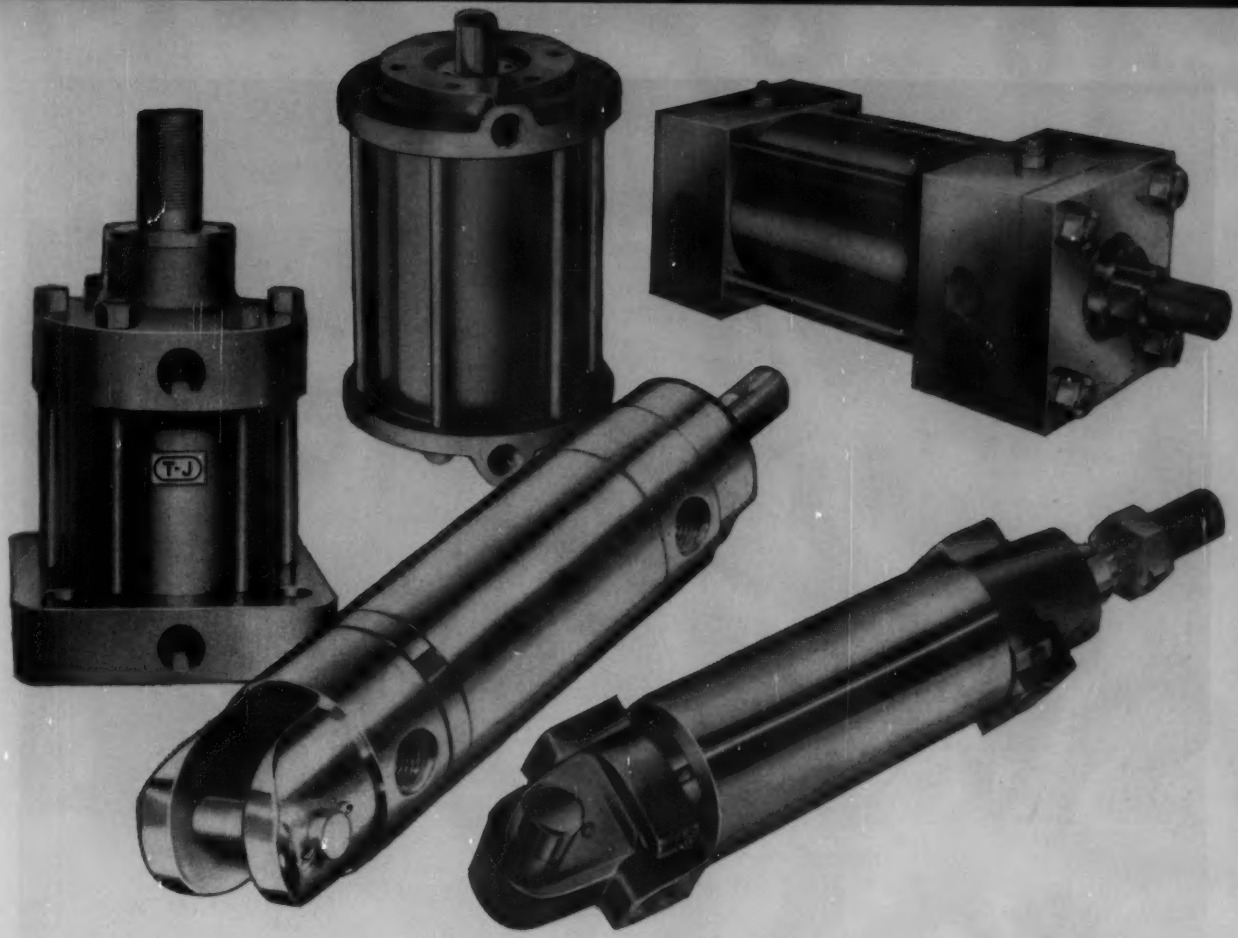
PARKER-KALON®

originator of the tapping screw

PARKER-KALON, a division of General American Transportation Corporation, Clifton, New Jersey. Offices and warehouses in Chicago and Los Angeles.

P-K® TAPITS Pat. Pendng

TEST P-K TAPITS FOR YOURSELF! ASK YOUR DISTRIBUTOR FOR FREE SAMPLES



For Your Power Drive • Design • Application or Replacement Maintenance

There's a T-J CYLINDER

That Can Assure *Accurate Efficient Operation*

Only T-J's complete line can assure you a cylinder of either air or hydraulic application – with practically limitless design specifications for bore, stroke, pressure range and even delivery requirement. From the time-tested, standard tie-rod air and hydraulic, to the exclusive T-J Spacemaker, and including the recently introduced Squair Head, T-J cylinders give you more features for efficient, long-lasting operation. Write today!

Plus

THE ONLY COMPLETE ENGINEERING CATALOG LINE, TOO!

H-47 for standard tie-rod hydraulic cylinders.

SQ-1058-4 for the T-J Squair Head cylinder.

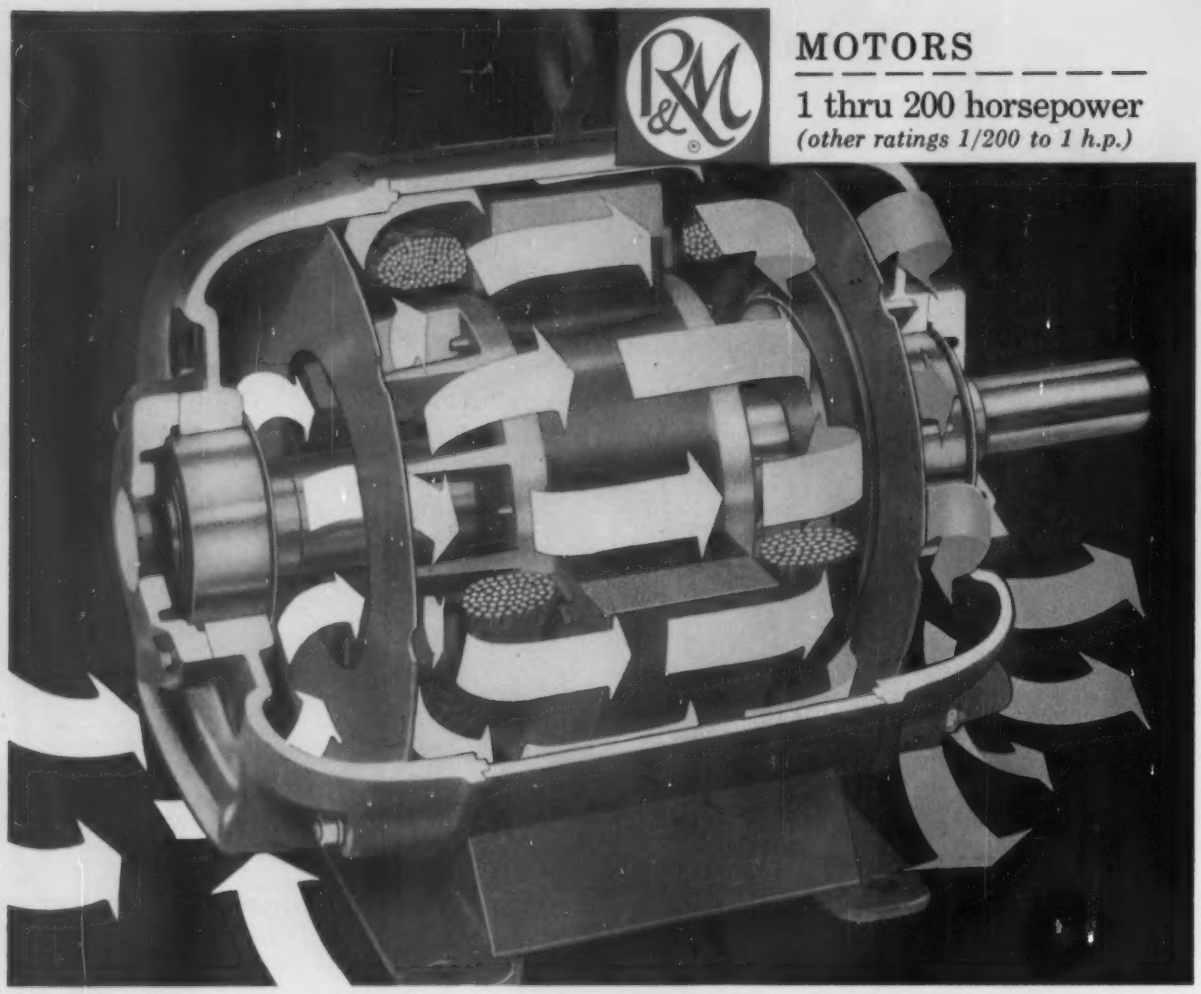
No. 54 for standard tie-rod air cylinders.

SM-56-3 for the incomparable Spacemaker cylinder.

HSM5-58-4 for the High-Pressure Hydraulic Spacemaker cylinder.

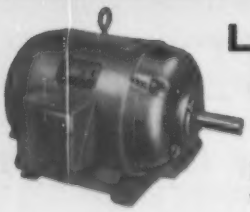
THE TOMKINS • JOHNSON CO. JACKSON, MICH.

CYLINDERS • MILLING CUTTERS • RIVETERS and CLINCHERS Circle 473 on Page 19



MOTORS

1 thru 200 horsepower
(other ratings 1/200 to 1 h.p.)

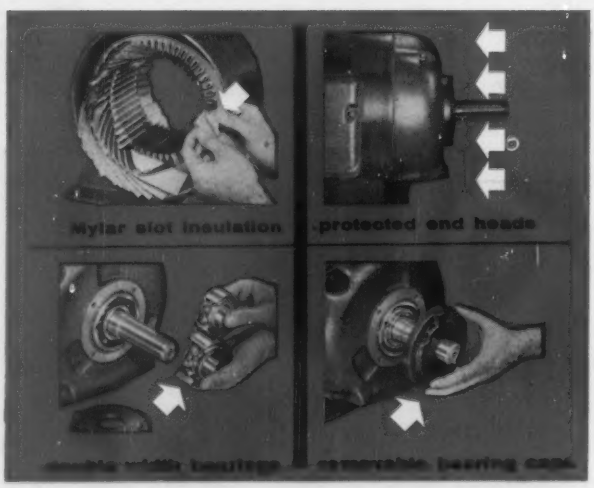


Longer Life because High Velocity *"Dual-Sweep"* ventilation *Cools and Cleans!*

ROBBINS & MYERS "Dual-Sweep" ventilation is a new concept in high velocity internal cooling and cleaning, designed to greatly prolong motor life. Tandem fans—one pushing, one pulling—create end-to-end ventilation that eliminates "dead" areas and converging air currents which deposit dirt. Venturi baffles at each end of the motor direct air in a washing action over and around end coils where it's most needed. Passages between field and outer shell form a "cylinder of air" which carries off motor heat.

R&M motors' long-life insurance also includes these features: Mylar* insulation that has 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . double width bearings with extra-large grease capacity . . . end heads that offer full height protection . . . removable caps for quick bearing inspection and re-lubrication. For details, write today for Bulletin 520 MD

**DuPont registered trademark*

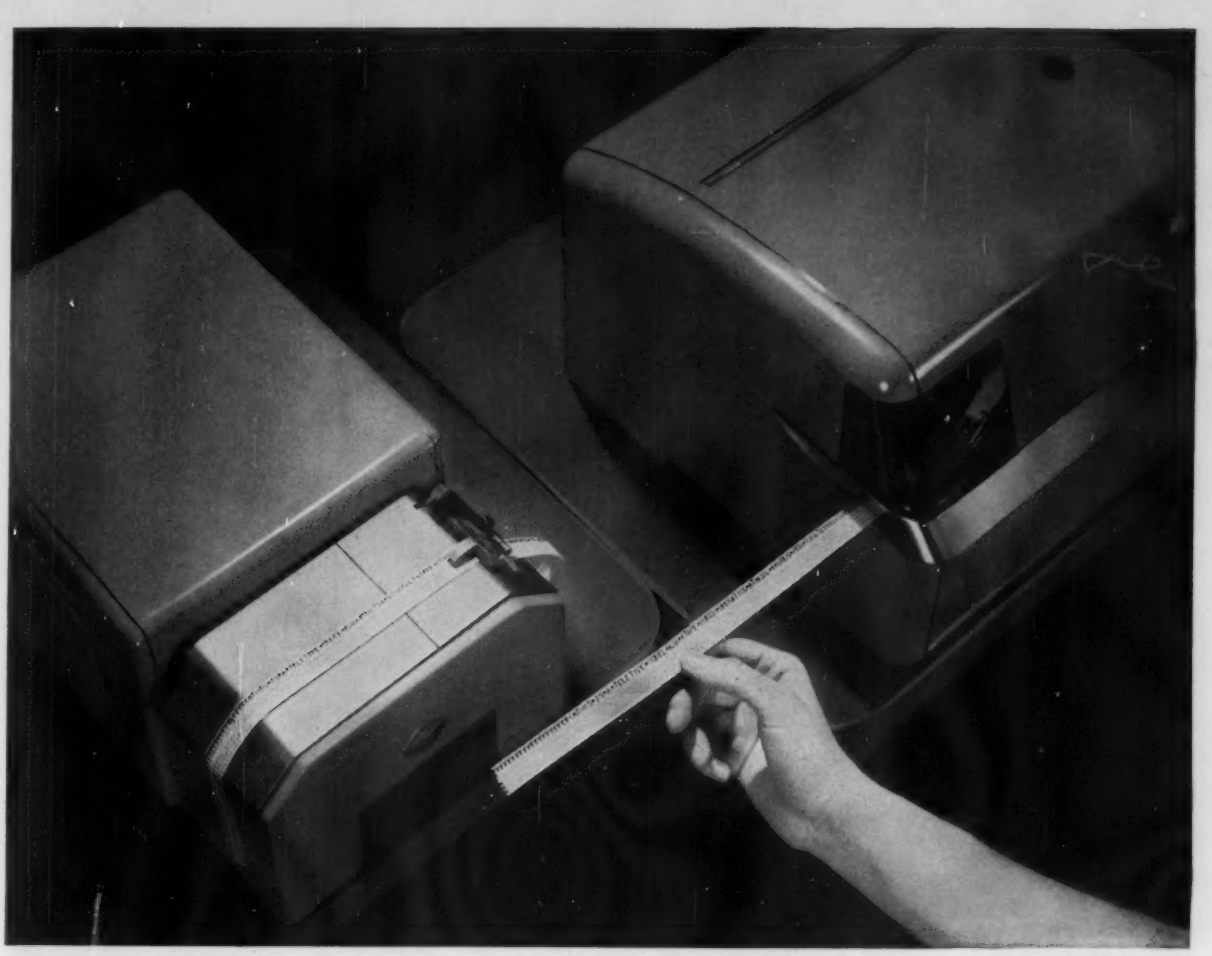


ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

Circle 474 on Page 19



Teletype Model 28 punched tape units

The Teletype Model 28 tape reader and typing tape punch combine proved dependability of operation with a variety of features which help streamline data communications systems and save the time of attendant personnel.

• *Convenience.* On the Model 28 tape reader, a single 3-position start-stop lever controls "on," "off," and "freewheeling." A specially designed tape lid, conveniently hinged, will accommodate either chadless tape or fully perforated tape, without intermediate adjustment.

The Model 28 tape punch not only perforates intelligence into tape—it simultaneously "prints out" the data right on the tape, thus greatly facilitating handling and storage.

• *Low Maintenance.* Both units are designed for extremely low maintenance, with all-metal clutches that require oiling only once or twice a year, depending on usage.

• *Reliability.* Teletype tape equipment is the product of extensive research and precision manufacturing facilities. It is made for continuous, day-in, day-out service with minimum upkeep. Teletype Corporation manufactures this equipment for the Bell System and others who require the utmost reliability from their data communications systems.

Typing Tape Punch

Tape Reader

Send-Receive Page Printer

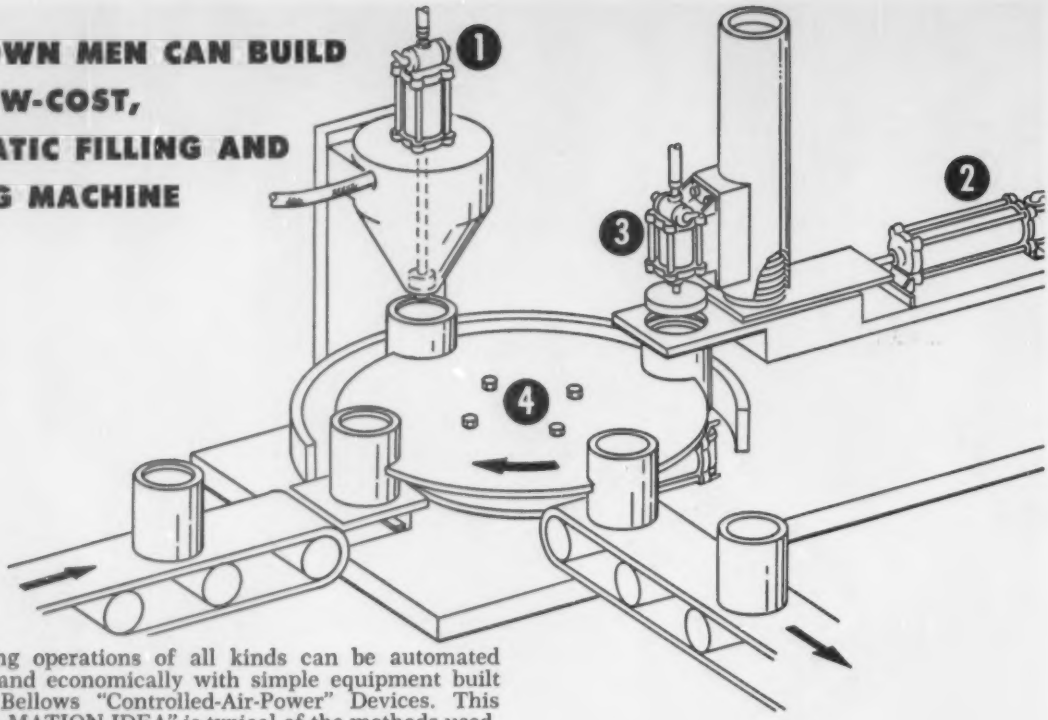
Automatic Send-Receive Set

FREE Model 28 line folder. Write Dept. 28H, 5555 Touhy Avenue, Skokie, Illinois.

TELETYPE®
CORPORATION
SUBSIDIARY OF *Western Electric Company* INC.

See Teletype Corporation's equipment exhibit at the Western Electronic Show & Convention, August 23-26, Los Angeles, California.

YOUR OWN MEN CAN BUILD THIS LOW-COST, AUTOMATIC FILLING AND CAPPING MACHINE



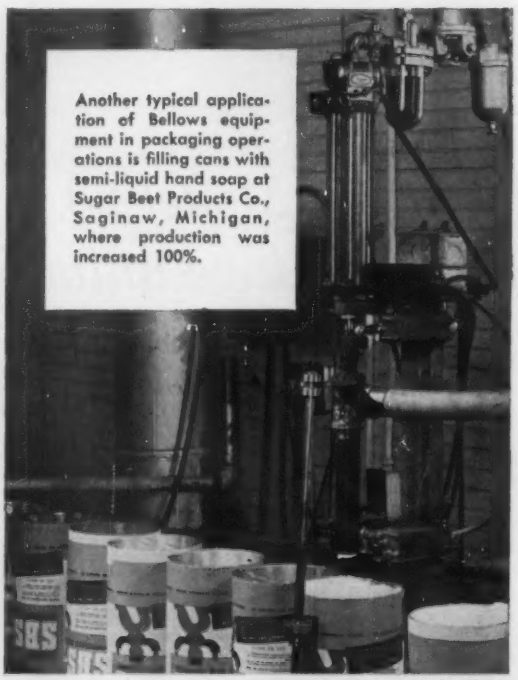
Packaging operations of all kinds can be automated quickly and economically with simple equipment built around Bellows "Controlled-Air-Power" Devices. This "SPOT-A-MATION IDEA" is typical of the methods used. Originally designed to fill and cap paint cans, it has been adapted to a variety of packaging operations. Bellows equipment has been used in packing and heat sealing plastic bags of sauerkraut, filling and capping glass pill bottles, and packaging granular material in paperboard containers, to cite a few examples.

In the sketch above, a belt conveyor feeds empty cans onto a Bellows Rotary Table equipped with a special top (#4), causing it to index through the work stations. After a container has been automatically positioned under the filling hopper, the piston rod of Bellows Air Motor #1 retracts, allowing paint to flow into the can. When a predetermined weight is reached, a limit switch is tripped and the piston rod advances to cut off the flow. At the next work station, Bellows Air Motors #2 and #3, operating alternately, deliver a lid to position and press it onto the can. At the last station, the filled and capped container is removed by a powered belt conveyor. All Bellows Air Motors are synchronized and electrically interlocked to assure proper timing and sequence of operations.

This is just one type of operation which Bellows Work Units can "spot-automate" simply and at low cost. Chances are there are scores of others in your plant. Why not investigate — *today*?

THIS SPOT-A-MATION IDEA FILE IS YOURS ON REQUEST

Contains installation data, wiring diagrams and equipment lists for the filling and capping machine as well as a score of other spot-automation applications of Bellows "Controlled-Air-Power" Devices. Write Dept. MD-860, Bellows-Valvair, Akron 9, Ohio.



Another typical application of Bellows equipment in packaging operations is filling cans with semi-liquid hand soap at Sugar Beet Products Co., Saginaw, Michigan, where production was increased 100%.

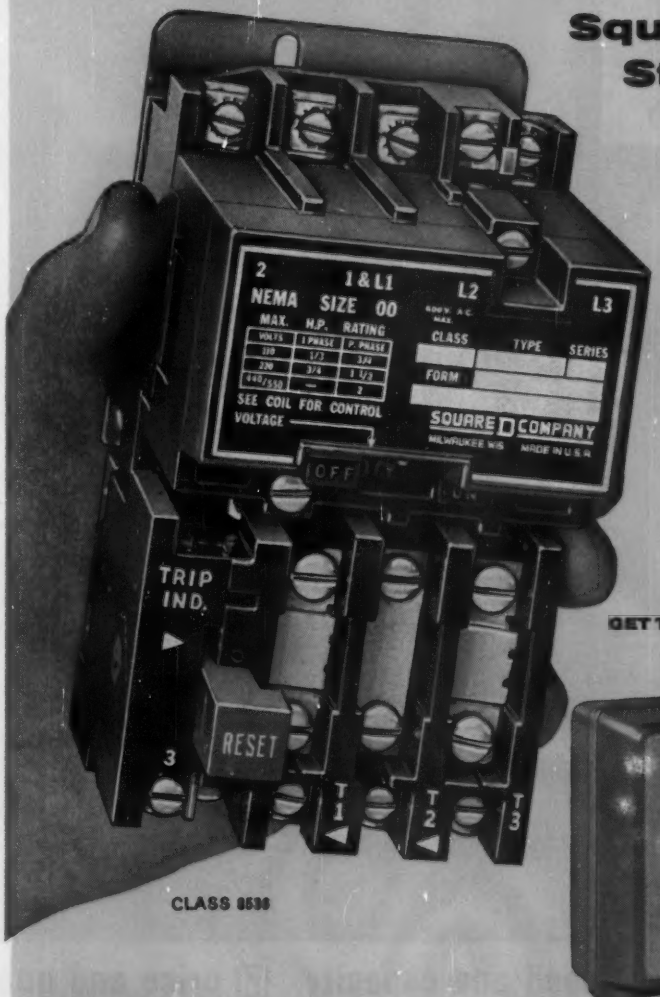
1445B-3

Bellows-Valvair

The Bellows Co. • Valvair Corp. *Akron 9, Ohio*

DIVISIONS OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

NEW SMALL MAGNETIC STARTER COSTS LESS, SAVES SPACE ON LOW-HORSEPOWER JOBS!



Square D NEMA Size 00 Starter Rated ¾ to 2 Hp for 3-Phase Service

• You no longer need to buy more starter capacity than you can use for low-horsepower jobs! This new Square D Size 00 starter is compact, easy to install, simple to use and maintain—and it costs 18% less than the Size 0 starter you formerly had to specify to get the advantages of magnetic control! With no sacrifice in quality, this new starter provides: straight-through wiring—pressure-type terminals—1-piece overload relays for complete motor protection—pushbutton or selector switch optional in the cover. Also available without overload relays.

GET THE COMPLETE STORY! Write for Bulletin SM-297. Square D Company, 4041 North Richards St., Milwaukee 12, Wisconsin.

New starter is available either open or in NEMA Type 1 enclosure. Enclosure shown with selector switch in cover.

SQUARE D COMPANY

wherever electricity is distributed and controlled

ONE MAN ONE TRADE ONE TOOL

...your production line back in operation in

30 SECONDS

(If it's a Hunt PDQ Air Control Valve)

☑ **accessibility** ☑ **simplicity** ☑ **speed and capacity** ☑ **price and quality**

Circle 478 on Page 19

No bulletin can do it justice... have the Hunt man call. Write to:

HUNT HUNT VALVE COMPANY DIVISION OF IBEC SALEM, OHIO

Quick-As-Wink AIR & HYDRAULIC CONTROL VALVES

ARCHIVE DESIGN
August 4, 1960

Job Recipes

ALMOST any job can be broken down into four essential ingredients: Initiation, decision, communication, action.

Every job accents one or more of these four factors. Main emphasis for a technician or draftsman, for instance, might be *action*—running a test, making a drawing, operating a computer. A salesman may spend all of his life on *communication*—transmitting facts and ideas from seller to buyer. An executive's job may be thought of as primarily *initiation* and *decision*.

An engineer is usually a man of *decision* and *action*. But perhaps he's moved to a supervisory job. All of a sudden, he's in work that requires emphasis on *communication*. Sometimes, like a poorly made cake, he falls flat.

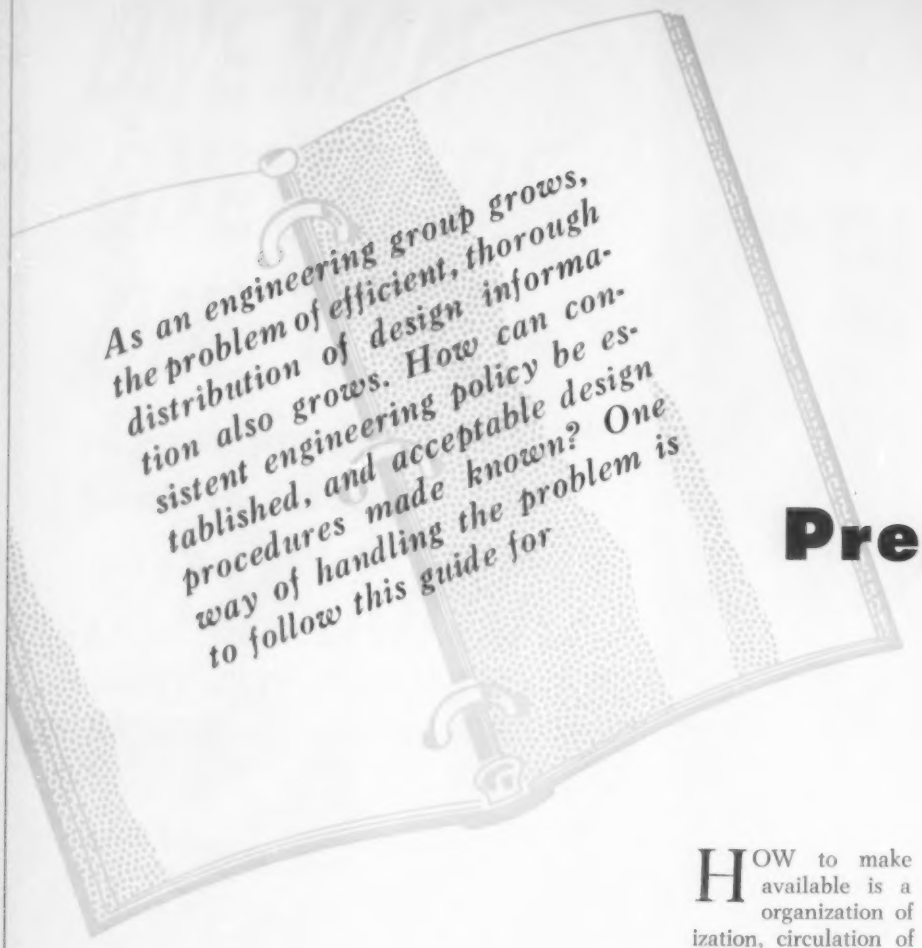
All of which points up a basic rule of life: If you're going to bake a cake, you've got to pick the right recipe. If a job calls for *communication*, you can't substitute *action*.

Despite its simplicity, this hard fact is not well recognized. Many engineers changing jobs, for instance, will examine type of work, wages, hours, benefits—but never once query what basic, innate talents the new job requires. And many an engineer goes on for years in his job without once changing his methods.

All of us need an occasional reappraisal of our "fit" with the requirements of a job. Maybe we're not supplying enough *communication*. Or perhaps we should be *initiating* new ideas or projects. Or maybe management is looking for a man with more *decision*-making capabilities.

In any case, the examination should help decide whether the job we're doing is a gourmet's delight—or just half-baked.

Robert L. Stedfeld
ASSOCIATE MANAGING EDITOR


As an engineering group grows, the problem of efficient, thorough distribution of design information also grows. How can consistent engineering policy be established, and acceptable design procedures made known? One way of handling the problem is to follow this guide for

Preparing a

R. W. BECKIM
Design Handbook Co-ordinator
Douglas Aircraft Co.
Santa Monica, Calif.

HOW to make design information readily available is a problem to an engineering organization of any size. For a small organization, circulation of the information by word of mouth or memorandums is generally sufficient. Similar methods will serve when there is little or no diversity of product.

However, increasing size of the organization, diversified production, or large personnel turnover may make some more suitable method of presenting design information necessary. Establishing a design handbook can provide the answer.

Advantages of a Handbook

Design handbooks offer several advantages:

1. Serve as a record of design decisions which may be applicable to future products.
2. Present the particular design methods acceptable to the company.
3. Aid in the education of new design employees.
4. Serve as a constant source of reference information for all design employees.

As a record of design decisions, the handbook reduces the number of decisions that must be made. For example, recommended maximum design stresses for a fastener for use in plastics are chosen. Once the choice is made and recorded in the handbook, all similar fastening problems can be based on the original decision.

A product always has some desirable characteristics which distinguish it from competitive products. When these special features are a result of design

Design Handbook

effort, the method of attaining them should be included in the handbook as required practice.

New employees in a design group may be well trained in the methods of a competitor or of a different industry. These methods are not necessarily applicable to their new company's design effort. Through use of a design handbook which sets forth practices acceptable to the company, both the training period and early supervision may be considerably reduced—and the employee has reassurance that his work will be acceptable to his new employer.

Without a design handbook, a designer must have the memory of an elephant or a drawer full of disorganized memorandums to keep all past design directives constantly in mind. A design handbook assures him of a ready reference in which he can quickly find all the set rules which may affect his work.

What the Book Should Contain

If a decision is made to provide a design handbook, the first step is to establish a well-organized outline of the data to be included. Outline headings should be general, distinctly different and descriptive, with details arranged logically under them. The outline should be co-ordinated by key design personnel and others who may be in a position to offer constructive criticism.

The type of information to be included will necessarily vary with the kind of product to be designed. A procedures section telling how to get various design jobs done may be necessary; this is usually easy, since it is merely a description of procedures or systems already in use. Such a section is especially useful to new employees.

The essence of a design handbook, however, must be design criteria—the "how, what, and why" of design practice. A design handbook should contain data on how to design the part, assembly, or product. For example, a sheet-metal part may be formed on a press brake, stamping press, hydropress, or by several other methods.

The design handbook should give enough information on the available forming equipment to indicate which method is most suitable for a given part. For example, some forming methods require an extra flange which is later trimmed off. A part requiring the full width of a sheet of metal could not be formed by this method for there would be no flange to insure proper forming.

If a part is wide enough and short enough, it can be formed on a press brake. If it is narrow, it can be roll formed. If the part must be of thick material, buying an extrusion may be a better solution.

A thick part, such as an extrusion which must be formed in the lengthwise dimension, can readily be given a curvature on a stretch press. However, the stretch press will reduce the cross section depending upon the amount of stretch. If this method is adaptable to the company's production system, the design handbook should carry information on cross-section reduction for the stretch press.

Sheet metal can be bent to a certain minimum radius depending on the alloy and the thickness. The design handbook might carry a table for each metal used showing the minimum bend radii versus

thickness for the different alloys of that metal. Aluminum alloy 3003 is soft and quite readily bent to a small radius. 1024-T is a harder alloy which comes from the mill in the heat treated condition and will crack if bent to the small radii possible for 3003 alloy.

Handbook information might indicate the type of part for which each alloy is suitable. For example, 3003 or 5052 aluminum alloys could be recommended for electronic cases and chassis but their use prohibited where structural strength is required. However, even where strength is a factor, 5052 may be acceptable for a welded part because the harder alloys such as 1024-T are not weldable, or are welded only with the greatest difficulty. All such information is valuable as design data.

Design data should answer the questions:

1. What shall the part or assembly be?
2. How shall it be fabricated?
3. Why are these recommendations made?

The answer to "why" may best be met by the method of presentation. For example, a chart showing the relative weldability of alloys is preferable to a list of alloys on which welding is permitted.

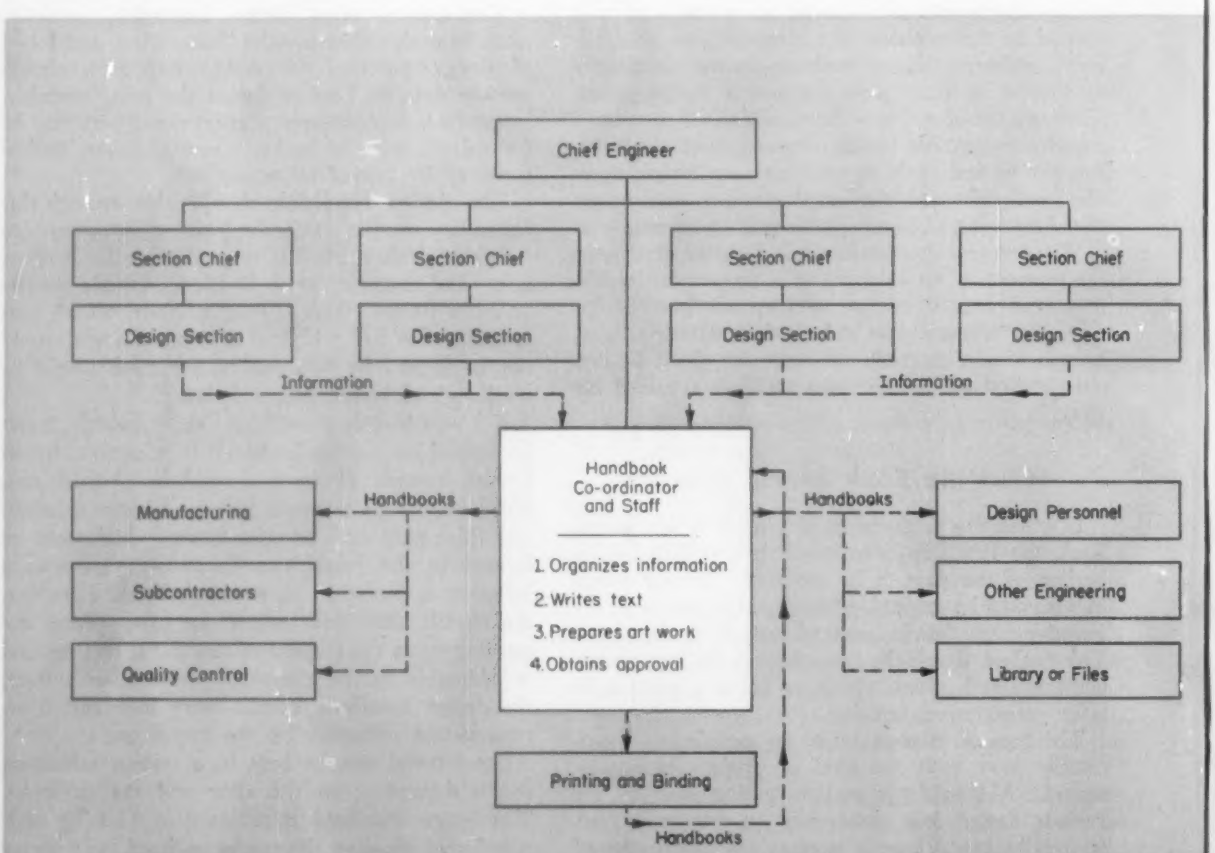
How Drafting Information Fits In: Drafting and design information can often be included in the same manual. As a company grows, however, the drafting sections are frequently separated.

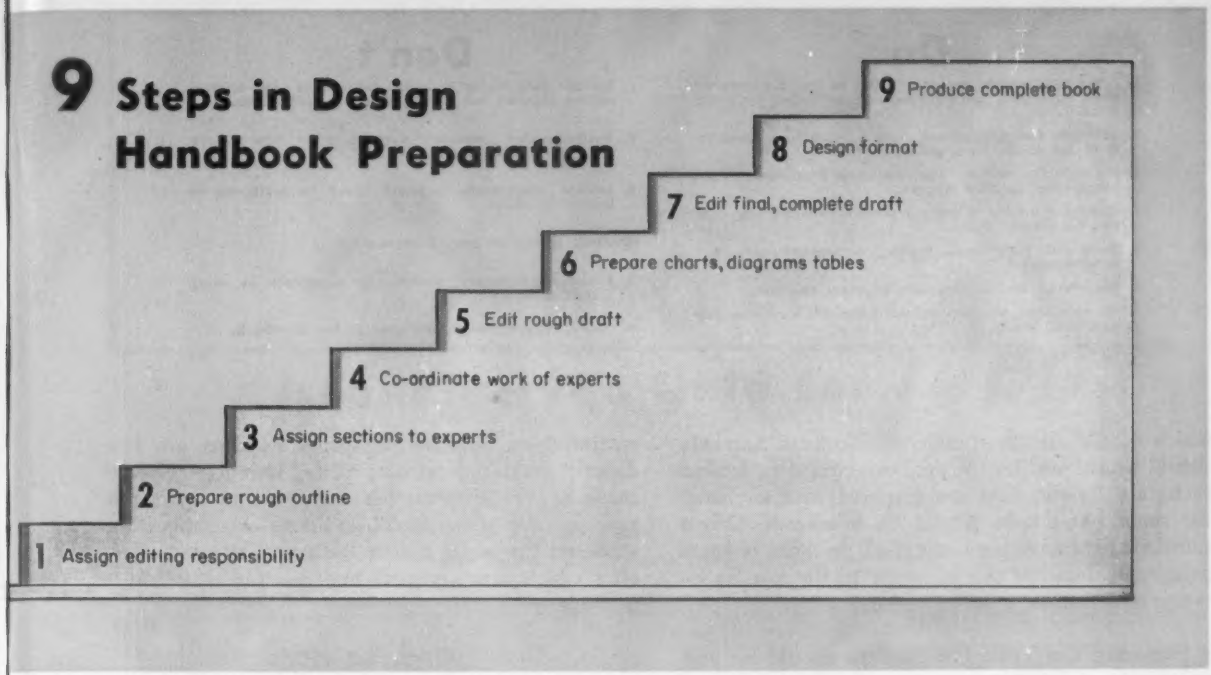
A drafting manual tells how many drawings must be made for each part, assembly, or final product. The types of drawing such as layout, assembly, or schematic are explained and the company rules for making them are included. In short, it tells how the design shall be shown, how many views, how much detail, and what this detail shall be.

Examples of these details might be: How to show left and right identical parts, how to show mating parts, or how to show fastener locations.

Standards: Sections of the drafting manual are sometimes called "drafting standards," just as sections of the design handbook are sometimes called "design standards." However, another type of data are more properly called "design standards." This type is found in a standards manual.

Basically, the standards manual is a collection of government, industry, and company standards. It may be included as a section of the design manual, or may be a separate volume. Most standards are parts or hardware such as fasteners, extrusions, tube fittings, and electrical parts such as resistors and condensers. However, some standards are not for a part but are for control of design practice. Examples are standard cutouts for electrical connectors and standard dimensions for flared tubing ends.




9 Steps in Design Handbook Preparation
1 Assign editing responsibility
2 Prepare rough outline
3 Assign sections to experts
4 Co-ordinate work of experts
5 Edit rough draft
6 Prepare charts, diagrams tables
7 Edit final, complete draft
8 Design format
9 Produce complete book

Organizing for Handbook Preparation

Once the kind of information to include in the handbook is determined, someone must be assigned the responsibility for its preparation. Ideally, this would be an experienced engineer with proved writing and organizational ability. However, this type of individual is rare and, when found, is generally in a responsible position with salary requirements too high for a handbook job. Generally, technical writers should not be assigned the job of preparing a design handbook, and engineers without a liking for writing soon return to straight engineering. The assignment usually involves some compromise, since no man can be an authority on all the information necessary for handbook preparation.

The handbook should be given to one individual as his prime responsibility. If it is assigned to someone who already has a full-time job, it will never get into print. Such work is often considered low-priority and is therefore easily shoved aside for more immediate demands.

After a man to pilot the handbook to completion is selected, the job must not be dropped there. People best qualified in the different subjects must be expected to produce design information in their own fields. For this purpose they must be allotted a specified time, or assigned a reasonable deadline or due date for the information they are to produce. Otherwise, the handbook will again be shoved aside for the press of day to day duties. A competent co-ordinator can accept drafts of proposed data in very rough form and rewrite them into final handbook form. However, he cannot be expected to supply missing information unless he is experienced in the particular field.

Design Handbook Group: If the company is large enough, there can be a design handbook group whose duty is to compile the data needed by all the design groups regardless of the product on which they are working. In this case, the design handbook usually notes where the design requirements change for different products or different design groups.

A large, diversified company will usually require a design handbook group, since the handbook generally grows into two volumes or sometimes even more. If it does, it may be divided arbitrarily on the basis of the number of pages that conveniently fit into a binder, or it may be divided by subject, such as mechanical design or electrical-electronic design.

Reviewing Handbook Data: Everyone will want to review the data before they go into the handbook. This can become a long and tedious process if it is not controlled. The number of people who review the data should be kept as small as possible without omitting anyone who could make a substantial contribution to the subject. However, it will be necessary for someone in authority to read all the data and sign his approval. This will give the handbook the status of company policy. Here again, it is easy to shove the handbook aside for more important work, so the reviewing authority should not be one who is already loaded down with other work.

Production Methods and Problems

When sufficient data have been compiled to make a presentable showing, the material should be issued to the design section. The binders selected should be a distinctive color and large enough to allow for expansion of data beyond the original outline. Dividers must be ordered. General headings from the original outline should be printed on the tabs

Do

1. Make your manual company policy so that the designer must have good and sufficient reason before deviating from it.
2. Schedule design handbook work so that time spent on it is not taken from other work.
3. Schedule the shortest practical route from design data preparation to final approval.
4. Make the volume a ready reference in which any data can be quickly found.
5. Keep all statements simple, straightforward, and understandable.
6. Use charts and illustrations wherever possible.
7. Be sure that all data prepared for the handbook has a specific use.

Don't

1. Include such highly technical subjects in your original outline that no one can be found to write them.
2. Assign design handbook work to those who already have a full time assignment.
3. Include educational material found in textbooks or taught in school.
4. Allow wordy or lengthy explanations.
5. Permit unnecessary reviews or approvals to delay design data.
6. Allow "space filling" material in the handbook.

which should also be numbered. Blocks of numbers should be assigned for the data expected to go behind each tab. As the data are prepared in final form, the main paragraphs should be numbered. When sufficient data have been compiled, an index of these paragraph numbers can be prepared for ease in locating information.

Preparing the Text: Design data should be prepared in brief, concise statements using as many tables, charts, and illustrations as possible. Data that can be prepared as a table or chart should never be presented as text. The text should not contain long and involved explanations because the designer will feel that he does not have time to read it.

The simplest approach is the typewritten text. Callouts and figure numbers may be more satisfactory if they are varitype or a similar lettering. Fold-out pages should be avoided; they make a messy handbook.

The final draft can be typed on 8½ x 11 pages and reproduced in the same size or on oversize sheets and reduced photographically. Typewritten text will be satisfactory if reduced as much as 1/3 from the original. The reduction tends to sharpen the type, but more than 1/3 reduction makes difficult reading because the letters are so small.

Art Work and Printing: The printing method most used for design handbooks is offset lithography. From the original typewritten page, an 8½ x 11 negative is made by direct photograph or by photo reduction of oversize pages. The offset printing plate is made from this negative.

Illustrations can vary from very rough sketches to the published work of an experienced illustrator. Generally, simpler types are used to start and the quality of illustration gradually upgraded.

Pencilled illustrations will reproduce adequately, but sharper and clearer illustrations result from inked originals, although the inking process is more time-consuming.

Photographs can also be used with the printing process outlined in this article. However, photographs frequently fail to give sufficient contrast to adequately emphasize the important points of the illustration.

After printing, the white master, the negative, and the printing plate are generally stored for use in reprinting or revising the page. Reprints are run directly from the printing plate. Deletions can be made by touching up the negative and making a new printing plate. Small additions or changes are made on the white master, generally by paste-over, after which new negatives and printing plates must be made.

Distributing the Handbook

Design handbooks should be made available to all design personnel since this is their main purpose. However, there will be many requests for handbooks from people outside the design section. These should be carefully screened to determine the need. All handbooks used outside the design section should be assigned to a supervisor even though they will be used by someone else. This avoids loss due to personnel changes.

The handbooks should have consecutive numbers printed on the binder at the time of manufacture. Card files listing distributed handbooks by number and by name of person to whom issued are then established. These are used as a record of distribution and as a guide for issuing revisions and additions.

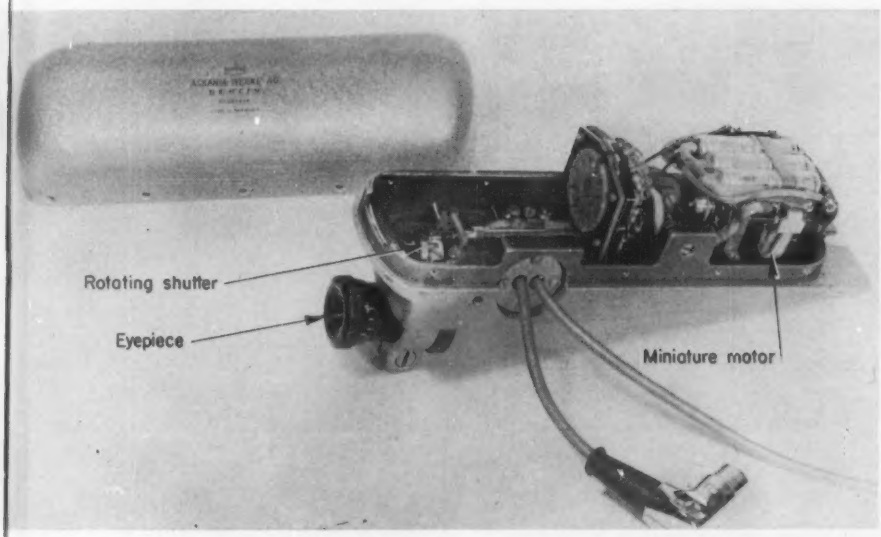
In adding new pages or revisions to a handbook, a small company may find it possible to distribute them directly to the handbook holders who will then insert them where necessary. Generally, however, this method is unsatisfactory. A more frequently used method places the additions and revisions in the handbooks by use of clerical help from an already existing clerical or filing group.

A Word About Cost

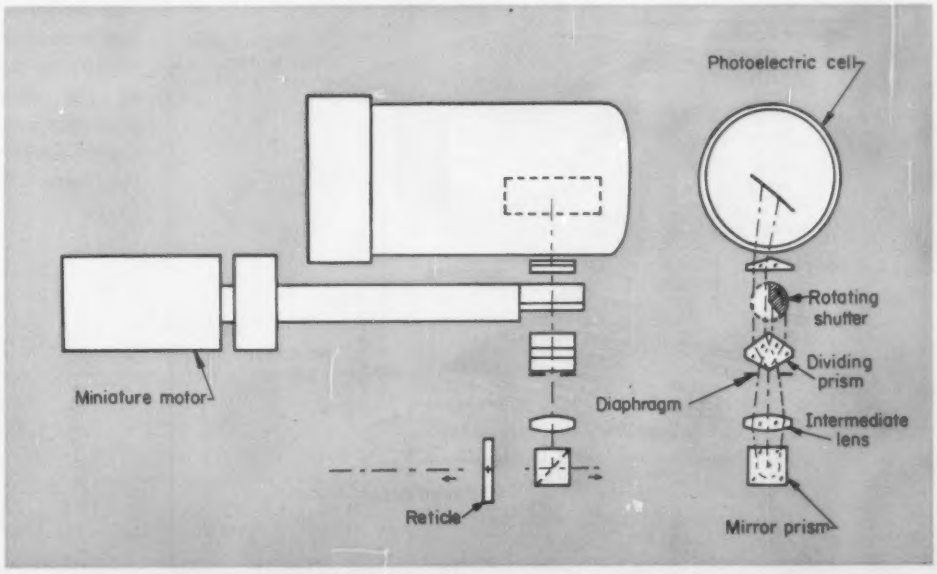
The first estimate may make the cost of establishing a design handbook seem exorbitant. Furthermore, it will be a continuing cost because the design criteria will constantly change as new methods and materials are developed. However, compared to the cost of past design errors which could have been avoided by better distribution of information, the handbook cost may become insignificant.

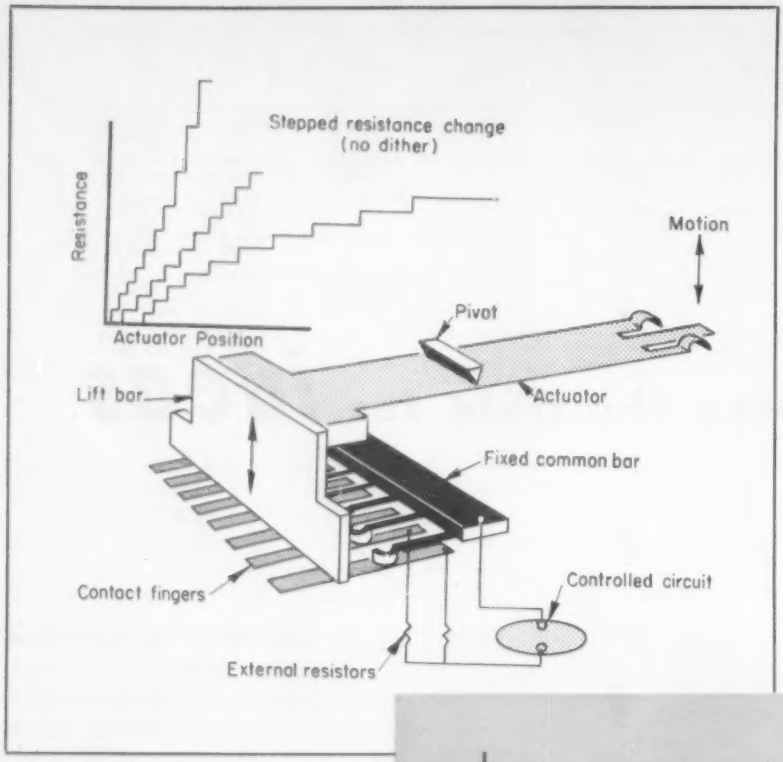
Do not undertake the creation of a handbook lightly. A constant and continuing effort is required. But with a well-organized and maintained handbook, design policy will be established clearly, and the efficiency of design procedures increased many times.

scanning the field for *ideas*

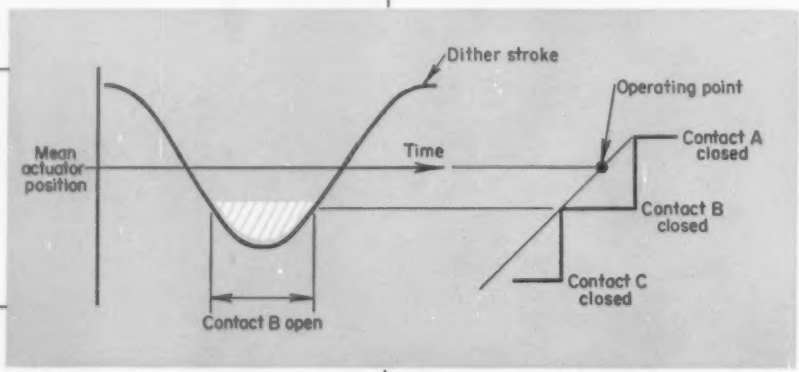


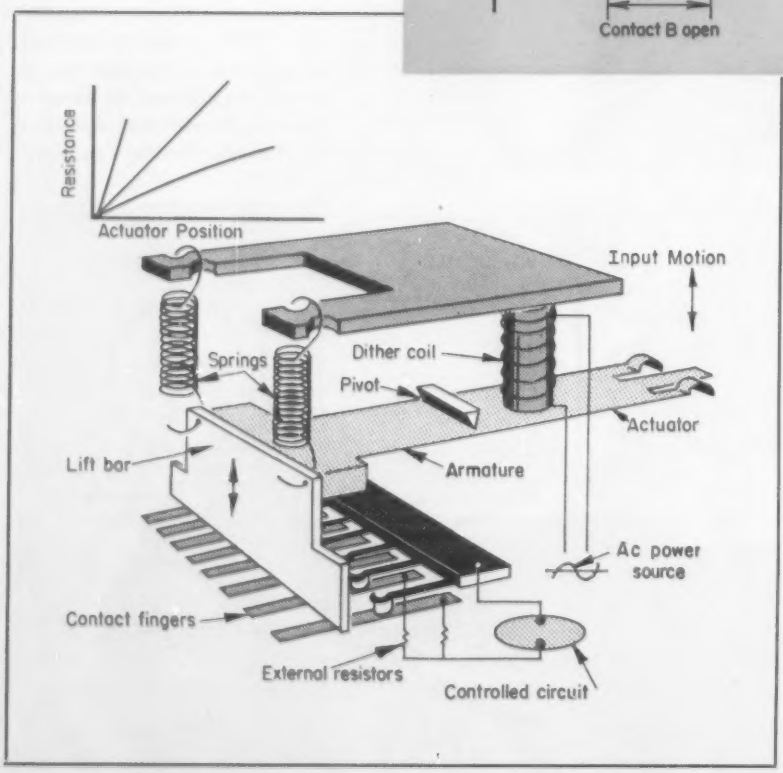
Split-field comparator permits precise centering of a point of light in a theodolite telescope. A dividing prism splits the image field. Each half of the field is alternately projected onto a photoelectric cell by a lens and rotating-shutter arrangement. An indicating instrument provides read-out of difference of signal intensities. Thus, when instrument has zero reading, the telescope is exactly centered on light source. Centering control principle employed in theodolite developed by Askania-Werke AG, Berlin, Germany.





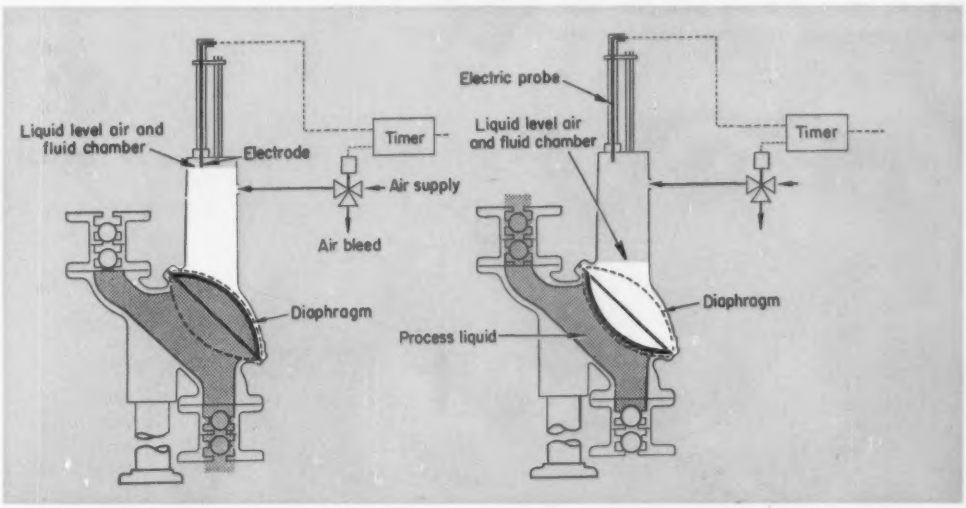
"Dithered" contacts produce stepless output from a stepped-contact transducer. A 60-cycle ac-power source drives a dithering coil connected to the lift bar. Thus, in addition to the usual contact operation, the bar also tends to open and close the contacts on either side of the one controlled by the position of the

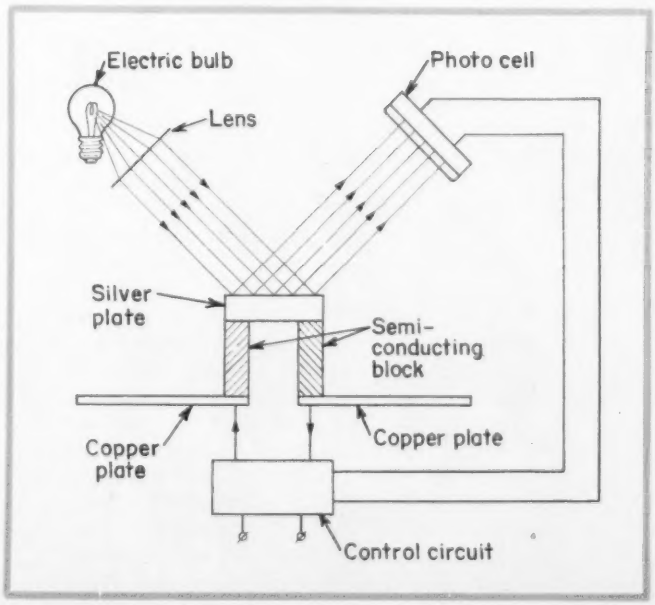




mechanical actuator. This action produces smooth and stepless resistance changes in response to mechanical motion of the actuator. Dithering principle employed in transducer developed by Electric Regulator Corp., Norwalk, Conn.

Liquid-contacting probe adjusts diaphragm stroke in a pneumatically-operated pump. Timed pressure and vacuum cycles in the upper chamber actuate a diaphragm to pump the process liquid. But signal received when conducting fluid in the upper chamber touches the probe, overrides the timer, and cuts off the exhaust cycle. Pump output is thus controlled by changing the probe depth. Principle employed in pump developed by Milton Roy Co., Philadelphia.

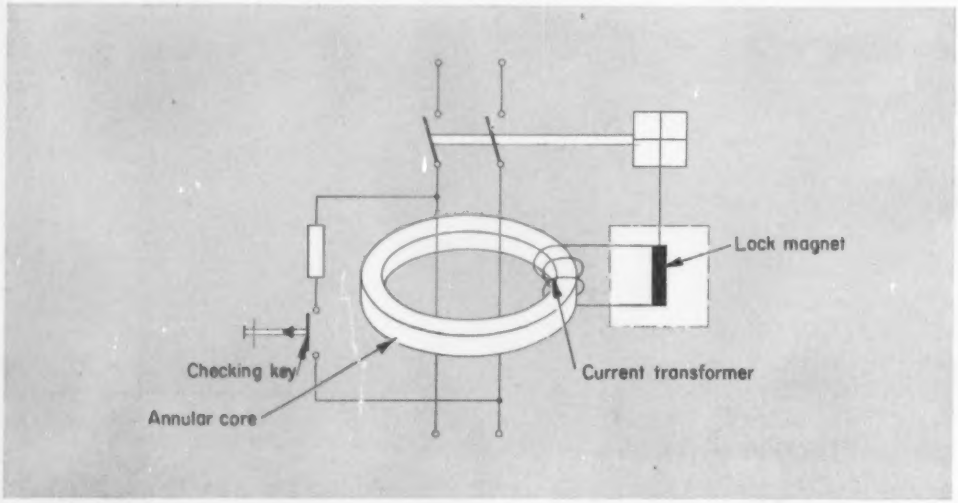


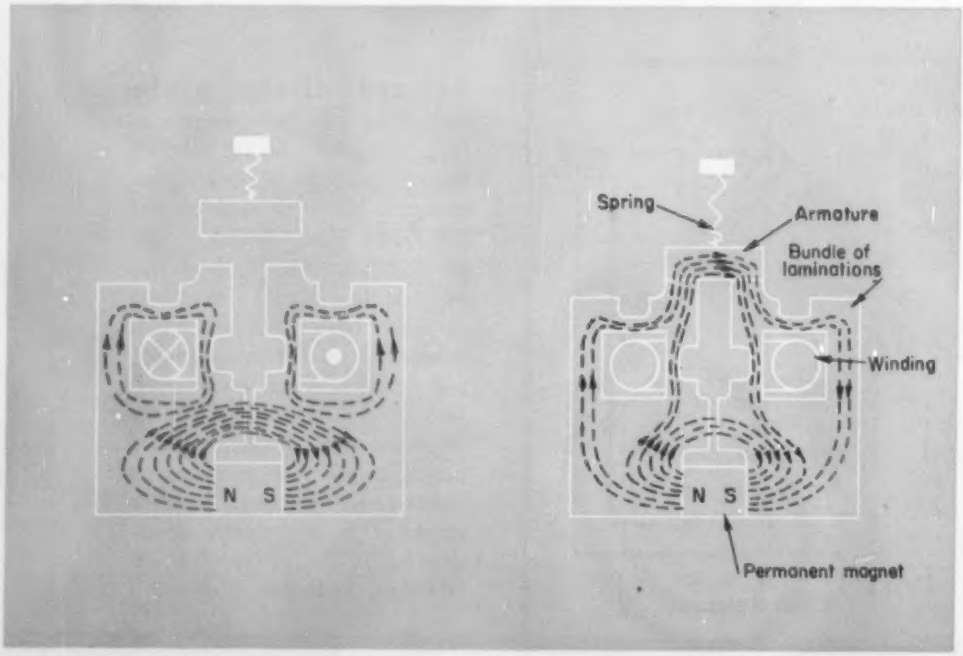


Servoed silver plate adjusts its own temperature to find dewpoint. Light reflected from polished plate powers photoelectric cell to produce current for Peltier effect cooling of the plate. When cooled to dewpoint, misty surface of the silver plate no longer reflects the light. Plate temperature rises, mist disappears, and cooling effect is renewed. One or two oscillations balance temperature at dewpoint. Thermocouple in plate measures its temperature. Cooling principle employed in hygrometer developed by NV Philips' Gloeilampenfabrieken, Endhoven, Holland.

SCANNING THE FIELD FOR IDEAS

Rerouted flux permits a spring to open a safety switch when the protected circuit is shorted. During normal operation, the armature is magnetically held in place. A short circuit unbalances the transformer, causing a current to flow, which produces a magnetic field in opposition to main field. Cancelled lines of flux free armature so that the preloaded spring can move it, along with the cutoff switch. Principle employed in switch developed by Siemens-Schukertwerke AG, Erlangen, Germany.





Electromagnetic Disc Clutches

How
load • torque • heating • cycling • controllability
affect their selection

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ELECTRICALLY controlled clutches are attractive in design applications because they provide smooth, shockfree engagement and disengagement, operate either dry or in oil, and occupy minimum space. Clutch mounting can usually be accomplished so that little inertia is added to the load to be accelerated. Stationary coil types which use no slip rings and brushes require minimum maintenance.

Clutches that are electrically operated are commercially available in five design types. See *Types of Electromagnetic Clutches*. This article deals with disc types only.

Clutch characteristics and selection procedure are outlined here. Often a clutch is selected on the basis of torque alone, whereas this should be only a starting point. If a clutch is to be used as a simple coupling on a noncyclic application, heating, response time, and controllability can probably be ignored. Obviously, the degree of importance of each factor varies from one application to another. A brief summary of the factors to consider for different clutch loads is given in Table 1.

Torque and Load

The first step in selecting a clutch is to determine what torque the clutch must transmit for satisfactory operation. To determine what clutch, in turn, is best suited for the load requires consideration of the complete torque characteristic of the clutch—pull-out, dynamic, and residual torques.

Maximum torque which the clutch is able to transmit before relative motion (slip) occurs between driving and driven parts is called running or pull-out torque. If the clutch were driving a load whose torque demand was continually increasing (such as a cutting load on a spindle drive), torque transmitted just prior to slow-down or stalling of the load is termed the running or pull-out torque. Once the clutch starts to slip, torque transmitted by the clutch is referred to as dynamic, starting, or slip

torque. Dynamic torque is, of course, equal to or less than pull-out torque. Dynamic torque is used to accelerate a load (or decelerate a load if used as a brake.)

Residual or drag torque is the torque transmitted when the clutch is de-energized. In most applications it is desirable to minimize this torque. Consequently, some means of reducing residual torque are provided in most clutch designs. The resulting magnitude of the residual torque depends on the effectiveness of the method used. For example, clip-type leaf springs are used in one design to separate the driving discs and provide running clearance for the friction (driven) discs.

In any application, a clutch should not be selected to meet just the exact torque requirements of the load but should provide some extra margin of torque. The extra margin or service factor required

Types of Electromagnetic Clutches

All electromagnetic clutches of commercial importance are composed primarily of three basic elements: 1. A rotor or driving member which is connected to the prime mover. 2. An armature or driven member which is connected to the load. 3. A magnetic-field producing member. Clutch types are determined by variations in both the configuration of these three elements and the principle by which torque is transmitted from the driving to the driven member.

Single Disc

The typical single-disc friction clutch is composed of a metallic armature and a rotor containing a friction surface of an organic material. When the field coil is energized with dc, the armature is attracted to the rotor. Torque is then transmitted by the frictional coupling between armature and rotor. Normally, this type of unit is built with a relatively large outside diameter and short axial length. It is usually designed for dry operation as opposed to operation with the friction surfaces running in oil.

Multiple Disc

To obtain an increased number of friction surfaces for torque transmittal, a disc pack is used in multiple-disc friction clutches. Alternate discs are connected to driving and driven members. When dc is applied to the field coil, the discs are drawn together either by magnetically applied mechanical force or by magnetic attraction. Torque is transmitted by frictional coupling between driving and driven discs. If all the discs are made of steel, the magnetic flux is usually directed through the discs themselves so that magnetic attraction holds them together. This type of unit is meant to run only in oil. If one of the sets of discs is provided with sintered-metal friction facings, the discs are drawn together by magnetically applied mechanical force. This type of unit can be run either with or without oil. The multiple-disc design results in minimum outside diameter but somewhat longer length.

Eddy Current

In the induction type of clutch, torque is transmitted by the interaction of two magnetic fields—one in the rotor or driven member and one in the armature or driving member. One of the fields is produced either by passing current through a field coil or by using permanent magnets. With relative motion between the two members, currents are induced in the second member to produce its magnetic field. Torque can be transmitted only when there is relative motion between driving and driven members. The amount of torque transmitted is a function of the slip or speed differential. For a given torque capacity, physical size of the eddy-current clutch exceeds that of the other types of clutches.

Magnetic Particle

In addition to rotor, armature, and field coil, the magnetic-particle clutch contains ferromagnetic particles which fill the space between driving and driven members. Depending on the design, the particles may or may not be suspended in a liquid. When the field coil is not energized, the ferromagnetic particles are randomly oriented and no torque is transmitted. When dc is applied to the coil, a magnetic field is set up within the clutch and through the particles. The particles are oriented by this field, and torque is transmitted from the driving to the driven member. The amount of torque that can be transmitted is a function of the magnitude of the direct current. For a given torque capacity, this design is bulkier than friction-type clutches.

Positive Engagement

Although similar in character to the friction type, the positive-engagement clutch transmits torque from the driving to the driven member by actual engagement or meshing of two plates which have matching face-type teeth. When dc is applied to the field coil, the magnetic field brings and holds the two toothed members together. Without question, this type of clutch transmits the most torque for a given physical size. However, it can be engaged only at low speed differentials.

depends on the type of load, the type of service, and the characteristics of the prime mover. Service factors suggested for various types of loads are given in Table 2.

A small machine (under 2 hp) that has a smooth, nonpulsating load of low inertia and is driven by an electric motor may require a service factor slightly greater than 1. Larger machines with the same type of load will require a service factor of about 2. When shock loads are encountered on these larger machines, or loads of a pulsating nature, or when cyclic rate or load inertia become high, the required service factor might be almost 3. If the prime mover is an internal-combustion engine, the service factors just recommended must be increased. An application using a diesel-engine prime mover with a severely pulsating load can require a service factor as high as 6. Obviously, each application must be studied carefully to permit selection of a clutch which is neither undersize nor oversize.

Another important load consideration is speed. Maximum recommended speed of a clutch should not be exceeded. In the slip-ring clutch, speed is usually limited by peripheral speed of the slip rings, because excessive speeds result in shortened brush life. In the stationary-field clutch, speed is limited by the clutch bearings or by centrifugal force. At slow speeds some clutch types will not function

Table 1—Guide to Clutch Selection and Application

If Load or Application Characteristics Are These . . .	. . . Investigate These Questions on Clutch Characteristics
Rapid cycling	Does clutch have sufficient torque to accelerate and decelerate load in required time (Equation 2)?
	Does clutch have sufficient heat-dissipating ability for the required cycles per minute (Equation 1)?
	Is a special control required to speed response (Fig. 5)?
High inertia load	Does clutch have sufficient torque to accelerate and decelerate load in required time (Equation 2)?
	Does clutch have sufficient heat-dissipating ability for the required cycles per minute (Equation 1)?
	Does clutch have sufficient thermal storage capacity to accommodate one acceleration or deceleration?
Control of torque	Is clutch torque versus current linear?
	Is torque controllable at low voltages and low speeds?
	Is torque consistent?
High speed	What speed limitations are imposed on the clutch by clutch bearings, or brushes and slip-rings?
	Is clutch torque at high speeds sufficient?
Low speed	Will clutch operate at low speed?
	Will it take excessively long for torque to build-up?
Operation of clutch at various speeds	If clutch torque varies with speed, will the clutch have the proper torque over the entire speed range?
Sensitivity to shock; load must be accelerated smoothly	Is clutch torque build-up smooth and not abrupt?
Utmost reliability	Can clutch be operated in oil?
	Can clutch selection be liberal?
Adverse atmosphere	Can protective cover be provided for clutch?
	Can clutch be operated in oil and the oil kept clean?
Small physical size for clutch	Can clutch with required attachments, such as output member, brushes, and slip rings, meet the size limitation?
Sensitivity to clutch inconsistencies, as for timing or indexing functions	Does clutch torque repeat as well as remain consistent with continued operation?
	Can clutch be operated in oil for maximum stability?
Sensitivity to stray magnetism	Does clutch construction lend itself to simple means of reducing stray magnetism?

properly or will take an excessively long time to engage.

In the single-disc clutch the torque which the clutch can transmit is a function of speed; hence, speed and torque must be considered together. In most multiple-disc clutches the torque which can be transmitted is independent of speed. Differences in the torque-slip speed relationships for these two clutch types are shown in Fig. 1. Slip is the difference in speed between driving and driven clutch members and is of particular importance when an inertia load must be brought up to speed or stopped quickly.

When the load must be accelerated as smoothly as possible, a clutch with a torque-time characteristic which is not abrupt during any portion of the torque build-up time is required. Generally speaking, the most successful in this respect is the multiple-disc clutch which uses sintered-metal friction discs and depends entirely on magnetic force to compress the disc pack. A typical torque-time relationship is shown in Fig. 2.

Total inertia of the load is another factor which must be carefully considered. Three basic questions involving load inertia and clutch capacity must be investigated:

1. Can the clutch accelerate the load to the required speed in the required length of time?
2. Can the clutch dissipate the energy losses generated during acceleration at its maximum cyclic rate?
3. If load inertia is rather high but the cycle rate low, can the clutch survive the temperature reached after accelerating the load even once?

Means for answering these questions are discussed later, but the questions are raised here to emphasize the importance of load inertia. Although its effects may be negligible in many cases, load inertia should always be investigated.

The electromagnetic friction clutch, like any friction device, is inherently a slip device. If machine or load requirements are such that this characteristic is not compatible with satisfactory machine operation, a tooth-type clutch should be seriously considered. This is often a difficult decision because, once fully engaged, the friction clutch will provide a one-to-one drive as long as the torque requirements of the load do not exceed the pull-out torque of the clutch.

Certain types of loads are more sensitive to clutch torque and response-time inconsistencies than others. Before a clutch is finally selected for such a load, consistency of clutch operation should be studied. In all friction clutches, torque is affected by temperature of the coil and the surface of the friction discs. However, if duty is consistent, temperatures will stabilize after a warm-up period and clutch operation should also stabilize. If the clutch is operated in oil, the excellent (compared to air) heat conductivity of oil maintains a more uniform clutch temperature and permits faster stabilization than if the clutch is operated in air. Hence, where consistency of operation is important, the clutch should be operated in oil.

Clutch Heating

Next to torque and load, clutch heating is the most important factor. However, in many applications, particularly those involving high cyclic rates and/or high load inertias, clutch size is governed more by heating limitations than by torque limitations.

Heat is generated in the clutch by electrical losses in the coil and by mechanical losses in the disc pack as a result of slippage during acceleration or deceleration. If the clutch remains energized for long

Table 2—Suggested Service Factors for Electromagnetic Friction Clutches

Type of Load	Service Factor*
Small machine tools (under 2 hp), small woodworking tools (under 2 hp), business machines. Loads are smooth, non-pulsating, and have low inertia and low cycle rate.	1.3 to 1.7
Large machine tools, large woodworking machines, textile machines, small presses, fans. Loads are smooth, non-pulsating, and have low inertia and low cycle rate.	1.7 to 2.2
Medium presses, centrifugal compressors and pumps, looms, printing presses, conveyors, blowers, small planers, tapping machines. Also, machine tools and woodworking machines whose loads are pulsating or are of high inertia and/or high cycle rate.	2.2 to 2.8
Large planers, broaches, shears, reciprocating pumps and compressors, plunger pumps, mixers, mills, agitators.	2.8 to 3.4

*These service factors are offered as a starting point in clutch selection when the prime mover is an electric motor. Character of the load, type of service, and operating conditions should be carefully examined before final clutch selection. For a four-cycle gasoline engine, multiply the service factors by 1.4; for a two-cycle gasoline engine or a diesel engine, multiply the service factors by 1.7.

periods of time, then heat generated by coil losses need only be considered. In such cases, the clutch should be so designed that it can be energized continuously without overheating.

If clutch operation is cyclic in nature, then mechanical heat losses produced by acceleration or deceleration of the load inertia must be considered. These losses can be calculated from

$$E = 1.7(WR^2)\left(\frac{N}{100}\right)^2 \qquad (1)$$

where E = heating energy losses during one acceleration or deceleration, lb-ft per cycle; WR^2 = total load inertia, lb-ft^2; N = speed to which the load must be accelerated or decelerated, rpm.

If the clutch must accelerate the load from a speed in one direction to the same or a different speed in another direction (as with a reversing planer or grinder table), losses can be calculated from Equation 1 if N is taken as the total speed differential.

Rate of heat generation is found by multiplying

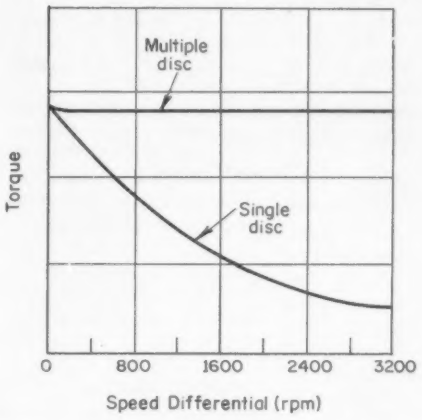


Fig. 1—Torque transmitting ability versus slip for typical single and multiple-disc electromagnetic friction clutches.

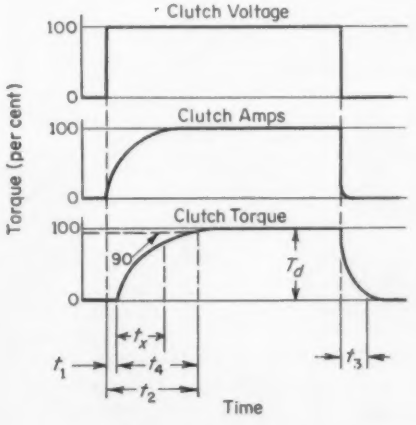


Fig. 2—Torque-time response of typical multiple-disc friction clutch using sintered-metal friction discs. Total build-up time t_2 is composed of lag time t_1, during which no torque is transmitted, and time t_4, during which the transmitted torque builds up smoothly toward steady-state dynamic torque T_d. Torque decay time is t_3, and t_x is some time interval less than t_4 (see Equation 3). When steel driving and driven discs are used, t_1 is usually a greater percentage of t_2, and slope of the torque curve is steeper tending to produce a more abrupt acceleration.

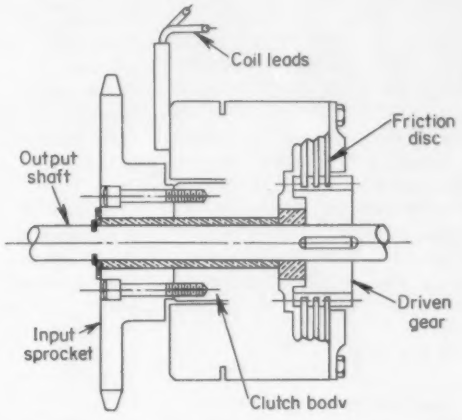


Fig. 3—Mounting arrangement for minimizing the amount of clutch inertia which must be added to load inertia. Constantly rotating input sprocket is attached to the clutch body, the higher inertia member. When the clutch is energized, low-inertia friction discs and driven gear are the only clutch parts which need to be accelerated

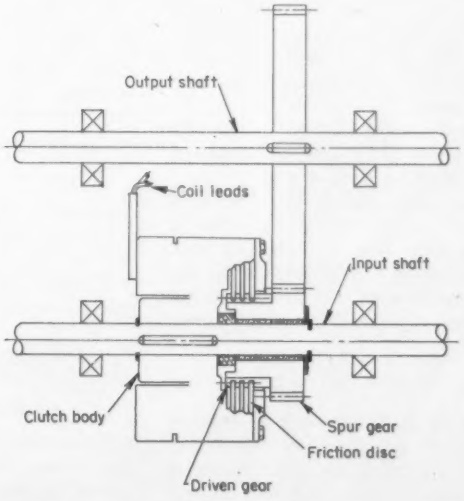


Fig. 4—Mounting arrangement for stationary-field clutch as part of a gear train. Clutch body is keyed to the constantly rotating input shaft. Only the low-inertia clutch-driven gear and friction discs need to be added to the load inertia.

Examples of Clutch-Heating Calculations

Application: A clutch is to be used inside the transmission of a machine. Driving portion of the clutch is attached to a shaft which rotates constantly at 1800 rpm counterclockwise. The driven end is connected to a spur gear which is part of a gear train that drives the load. Load inertia reflected back to the clutch is 4.8 lb-ft^2; inertia of the driven end of the clutch is 0.2 lb-ft^2. Thus, total inertia the clutch must accelerate is 5 lb-ft^2.

Example 1: The drive is so arranged that, when the clutch is not energized, the driving end of the clutch rotates at 1800 rpm and the driven end of the clutch and the load do not rotate. When the clutch is energized, it must accelerate the load. After 5 sec, the clutch is de-energized and a separate brake stops the load. This is repeated at the rate of 5 times per min.

From Equation 1, the heating energy losses per cycle are

$$E = 1.7(5)\left(\frac{1800}{100}\right)^2$$

$$= 2740 \text{ ft-lb per cycle}$$

Rate of heat energy generation, E/m, is

$$\frac{E}{m} = 2740(5)$$

$$= 13{,}700 \text{ ft-lb per min}$$

The heat losses are compared with the data on heat-dissipating ability supplied by the clutch manufacturer, and the proper size clutch is determined. The brake would have the same E and E/m as the clutch.

Heat-dissipating ability is generally given either as a rate of continuous heat dissipation (such as ft-lb per min) for each size unit or as a curve of allowable ft-lb of energy per cycle for various cycle rates for each size unit. Typical curves are shown in the accompanying figure. For convenience, the following conversion factors are given:

Btu × 778.3 = ft-lb
hp-sec × 550 = ft-lb

Example 2: The drive is so arranged that, when the clutch is de-energized, the driven end of the clutch rotates at 1800 rpm clockwise, and the load rotates at a corresponding speed and in a corresponding direction. When the clutch is energized, it must reverse the rotation of the driven end and the load and drive the driven end of the clutch at 1800 rpm counterclockwise and drive the load at a speed and in a direction corresponding to this. In Equation 1, $N = 2 \times 1800 = 3600$ rpm, and

$$E = 1.7(5)\left(\frac{3600}{100}\right)^2$$

$$= 10{,}960 \text{ ft-lb per cycle}$$

$$\frac{E}{m} = 10{,}960(5)$$

$$= 54{,}800 \text{ ft-lb per min}$$

The clutch that is selected must have adequate heat-dissipating ability to handle the calculated heat losses. Note that heat losses during a reversal are four times those encountered during one acceleration.

Example 3: The drive is so arranged that, when the clutch is de-energized, the driven end of the clutch rotates at 900 rpm counterclockwise and the load rotates at a speed and in a direction corresponding to this. When the clutch is energized, it must accelerate the load from 900 rpm counterclockwise to 1800 rpm counterclockwise. For this condition, $N = 900$, and

$$E = 1.7(5)\left(\frac{900}{100}\right)^2$$

$$= 685 \text{ ft-lb per cycle}$$

$$\frac{E}{m} = 685(5)$$

$$= 3425 \text{ ft-lb per min}$$

Note that in Example 2, clutch size selection would almost surely be determined by heating considerations whereas in this example, heating would play a relatively minor role.

Example 4: Consider the same drive arrangement as in Example 1 except the load inertia reflected back to the clutch is 200 lb-ft^2 and the cycle rate is only once per hour. Then,

$$E = 1.7(200)\left(\frac{1800}{100}\right)^2$$

$$= 109{,}600 \text{ ft-lb per cycle}$$

Although total heat generated in this case in one hour is much less than in any of the previous examples, heat energy in one cycle is much greater. Thus, before a clutch is finally selected, both continuous heat-dissipating ability and "one-cycle" thermal-storage capacity should be checked.

Example 5: To illustrate the importance of the inertia of the driven portion of the clutch, assume that the same drive arrangement of Example 1 is used except the cycle rate will be 50 cycles per min and load inertia will be 0.3 lb-ft^2. Inertia of the driven end of the clutch is to remain 0.2 lb-ft^2. Total inertia to be accelerated is then 0.5 lb-ft^2. Thus,

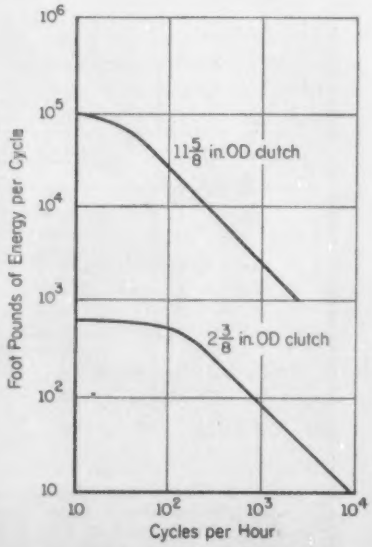
$$E = 1.7(0.5)\left(\frac{1800}{100}\right)^2$$

$$= 274 \text{ ft-lb per cycle}$$

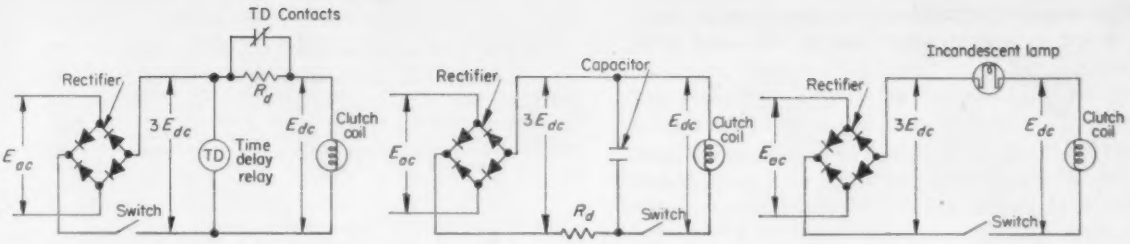
$$\frac{E}{m} = 274(50)$$

$$= 13{,}700 \text{ ft-lb per min}$$

The rate of heat generation, E/m, is the same as in Example 1. However, in Example 1, only 4 per cent of the heat energy resulted from clutch inertia while in this example it is 40 per cent. Obviously, an application involving low load inertias and high cycle rates should have the clutch so mounted that only the low-inertia end is accelerated—the high-inertia end should be constantly rotating. Also, inertia of the clutch selected should be as low as practical.



Typical presentation of heat-dissipation information for electromagnetic clutches. Maximum allowable heat energy per cycle is plotted against rate for two sizes of clutches. Clutch rating for lower curve is 40 lb-in. of starting torque dry; for upper curve, 26,000 lb-in. of starting torque dry.



a—When the switch is closed, dropping resistor R_d is shorted out and overvoltage is applied to the clutch. After a fraction of a second, TD contacts open and current flows through R_d. The voltage drop across R_d then results in rated voltage being applied to the clutch. The time-delay relay and contacts could be replaced by a switch which was timed to open slightly after the actuating switch closed.

b—An initial high-voltage surge is provided by the condenser when the switch is closed. As current flows through resistor R_d, the voltage drop cross R_d increases as its temperature rises, and voltage across the clutch coil decreases proportionately. When steady-state conditions are reached, rated voltage is applied to the clutch.

c—In this circuit the filament resistance versus temperature characteristic of an ordinary incandescent lamp is used. When the switch is closed, lamp resistance is low and high voltage is applied to the clutch. In a fraction of a second, filament temperature rises, and the voltage drop across the lamp increases so that rated voltage is applied to the clutch coil. If a carbon-filament lamp is used, exactly the opposite effect is obtained because resistance of the carbon filament decreases with an increase in temperature.

Fig. 5—Three common circuits for applying momentary overvoltage to a clutch to speed its response.

the losses per cycle by the number of cycles per minute. This rate should not exceed the clutch dissipating ability. Application of heating rate and Equation 1 are illustrated in *Examples of Clutch-Heating Calculations.*

In heat calculations, total inertia of the system to be accelerated should be used and must include those portions of the clutch which must also be accelerated. Hence, inertia of the clutch itself is important since, in a borderline case, it can add enough inertia to the system to require use of a larger clutch. Obviously then, the clutch should be mounted in such a way as to minimize the clutch inertia that must be added to load inertia. Mounting arrangements which accomplish this are shown in Fig. 3 and 4.

If results of the heating calculation indicate that a clutch which has been selected on the basis of torque capacity will be overheated, the following alternatives are available:

1. If the clutch is used in oil, cool the oil sufficiently (using a heat exchanger if necessary) to keep the clutch within safe thermal limits.
2. If the clutch is operated in air, provide sufficient forced ventilation to keep the clutch within safe thermal limits.
3. Select a larger size clutch.
4. Reduce cycle rate, inertia of the system, or speed sufficiently to bring the application within safe thermal limits.

Where cyclic rate is low but load inertia is large, heat generated during one acceleration or deceleration may exceed the storage and dissipation abilities of the clutch. In such applications, recommended maximum energy for one clutch start should be observed.

Although maximum allowable coil and friction-disc temperatures vary for different types of clutches, normal limiting temperature for the coil is 105 to 120 C and for the friction discs, 150 to 200 C.

Cycle Time

If a clutch is required to complete a cycle in the shortest possible time, or to complete many cycles in a short period, the length of time it will take the clutch to accelerate the load and complete the cycle must be determined. Factors which influence total cycle time are: Clutch torque build-up time; clutch torque decay time; total inertia of the system;

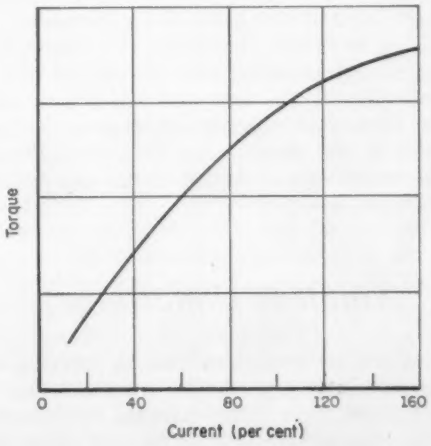


Fig. 6—Torque-current relationship for a typical multiple-disc electromagnetic clutch using sintered-metal friction discs.

friction load, if any, during the accelerating and decelerating period.

Time required to accelerate or decelerate an inertial system to a given speed can be calculated from

$$t = \frac{N_C(WR^2)}{308\,T} \qquad (2)$$

where t = time to accelerate or decelerate the load, sec; N_C = change in speed which must be produced in the load inertia, rpm; T = clutch torque available, lb-ft.

If there is an appreciable load torque during the accelerating or decelerating period, this torque must be subtracted from clutch torque T during acceleration or added during deceleration.

For a clutch having an exponential torque-time characteristic, Fig. 2, the average torque available for acceleration or deceleration during torque build-up period t_4 is $0.61T_d$.

If the relationship of load inertia and clutch torque is such that the load reaches its final speed before the clutch torque build-up period has expired, then the average torque available for acceleration or deceleration during any portion (t_x) of the torque build-up time can be found from

$$T_a = \frac{T_d t_4}{2.3\,t_x}\left(\frac{2.3\,t_x}{t_4} + e^{\frac{-2.3\,t_x}{t_4}} - 1\right) \qquad (3)$$

where T_a = average torque transmitted during period t_x, lb-ft; e = natural logarithm base; T_d and t_4 are as shown in Fig. 2.

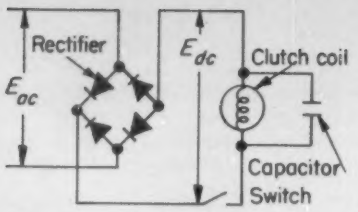
With response characteristics of the clutch known, Equations 2 and 3 can be used for accurate determination of the time required to complete a cycle. This analysis applies to clutches in which the torque transmitted is independent of speed. If clutch torque is a function of slip speed, analysis becomes more complicated since clutch torque then varies with both time and slip speed.

Response time of most clutches can be increased by using a control circuit which applies overvoltage to the clutch during the torque build-up period. Typical control circuits which accomplish this are shown in Fig. 5. For any case where a clutch is selected for a rapid cycling application, the characteristics of the clutch must be well understood, and the consistency of clutch torque and response must be considered.

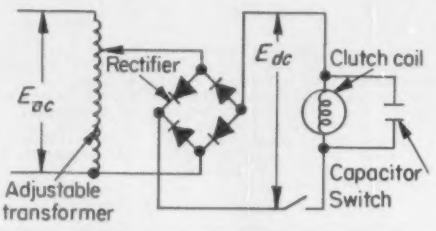
Ambient Conditions

One of the early considerations in applying electromagnetic clutches is whether the clutch is to be operated in oil, as a clutch mounted inside a gearbox. The type and quantity of oil used should conform to manufacturer's recommendations. Actually, the relationship of oil to friction material is rather complex.

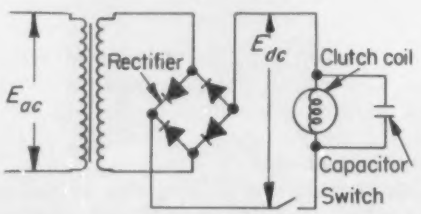
Automatic transmission oils or plain mineral oils



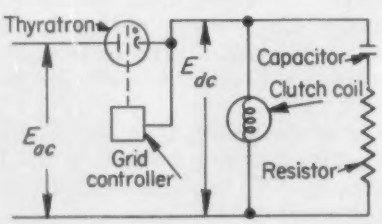
a—Simplest circuit supplies ac directly to the rectifier. Clutch coil is wound to match the dc output voltage of the rectifier. For example, with 115-v ac supplied to a standard full-wave rectifier, output is 90-v ac. The capacitor protects the switch by absorbing the energy in the magnetic field which otherwise would arc across the switch contacts when the switch is opened.



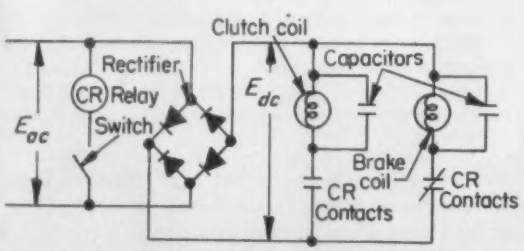
b—Adjustable transformer varies the voltage to the rectifier and, hence, varies dc output. This circuit would provide clutch torque control. The transformer can be manually adjusted or be mechanically linked to some part of the machine for automatic control.



c—When ac supply voltage is other than 115-v ac (such as 220, 440, or 550 v) and a standard 90-v dc clutch is to be used, a transformer is placed ahead of the rectifier to provide a 115-v ac supply. A step-down transformer can also further reduce ac supply voltage. For example, a 24-v dc clutch is often used with slip rings in oil.



d—Thyratron tube is used to rectify the ac supply voltage. This arrangement is often selected so the tube grid can be used as part of a closed-loop control.



e—An electrically operated brake is also controlled with this combination circuit. When the switch is open, the relay is de-energized and the normally closed relay contacts apply power to the brake. When the switch is closed, the relay is energized, the brake is released, and power is applied to the clutch coil.

Fig. 7—Basic circuits for obtaining dc power for the clutch coil.

are normally recommended. Addition of rust inhibitors, oxidation inhibitors, and antifoam agents is permissible. However, oils with sulfur, chlorine, lead, or sulfurized fatty materials should be avoided because they sometimes react with the sintered friction material. Viscosity of the oil should be about SAE 10 or SAE 20—too thick an oil causes the clutch to act sluggishly and fails to get in between the discs as it should. In any event, the oil should be kept as cool and clean as practical.

The method of applying oil to the clutch can vary from a simple dip into the oil to an oil spray on the clutch or an oil-mist atmosphere. If the clutch is designed to be used either dry or in oil, the effectiveness of the method of getting oil on the clutch in an oil atmosphere is not extremely

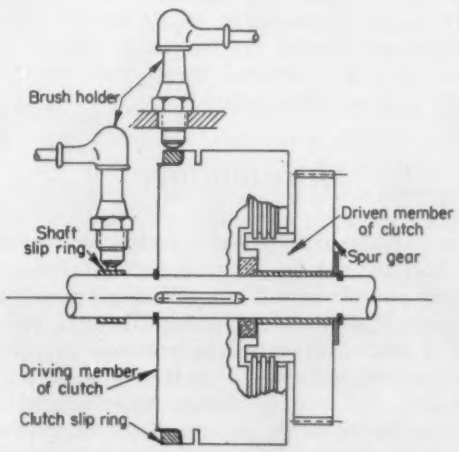


Fig. 8—Typical mounting arrangement for slip-ring clutch where electrical power is supplied to rotating field through brushes and slip rings. Clutch driving member is keyed to input shaft; driven member is attached to a spur gear which is part of the machine gear train.

critical. However, if the unit is designed only for an oil atmosphere (as with driving and driven discs of steel), particular care must be exercised to insure an adequate amount of oil to every clutch in the gearbox. If an oil dip is used, too much oil will cause churning and will result in excessive oil heating, particularly at high speeds.

If the unit is designed only for operation in a dry atmosphere, oil must be prevented from getting on the friction surfaces, or ultimate failure of the clutch will result. Again, if the unit is designed for both wet and dry operation, some amount of oil will not be detrimental. In general, operation in oil is preferred since wear is greatly reduced and the added cooling effect of the oil allows heavier loading of the unit.

Ambient temperature must also be considered since excessively high or low temperatures can cause clutch failure. As a general precaution, if ambient temperature is expected to exceed about 40 C or be less than 0 C, the manufacturer of the clutch should be consulted before attempting to use the clutch under such conditions.

Excessive dust, lint, moisture, dirt, or chips can substantially reduce clutch life. When these contaminants are present, some form of protective enclosure should be provided. However, the design of such an enclosure should permit heat generated by the clutch to escape. If a slip-ring clutch is being considered, the brushes and slip-rings must be protected from abrasive dust to prevent accelerated wear of both the brushes and the rings.

Controllability

One of the demands frequently imposed upon modern electromagnetic clutches is that of controllability, which usually means torque control. Torque control is required where torque must be applied slowly to accelerate or decelerate a load smoothly and without shock. It can also be an advantage where torque transmitted must be accurately limited to maintain a certain tension in a roll of material or to achieve a predetermined tightness when two threaded parts are automatically being screwed together.

Torque output control is usually achieved by controlling clutch current. Normally, the best torque-current characteristic for a clutch has a linear torque output with respect to current up to and somewhat beyond full current. For example, Fig. 6 shows the torque-current characteristic for a typical clutch which uses sintered-metal friction discs and which depends entirely on magnetic force to compress the disc pack. When steel driving and driven discs are used and magnetic flux passes through the disc pack, the torque-current characteristic is S-shaped with only a slight torque build-up between 0 and about 50 per cent current. Then, a sharp torque increase occurs between 50 and 80 per cent current, followed by a gradual flattening of the curve. The torque-current curve for a single-disc clutch is similar to Fig. 6.

For a controlled-torque application, other clutch characteristics should be examined in addition to the torque-current relationship. Controllability at low values of current and at low speeds should be checked. The effect of the nonlinear speed-torque relationship in the single-disc clutch should also be considered. Effects of usage and wear-in on pertinent clutch characteristics should be recognized since any changes these factors produce in clutch

characteristics will necessitate periodic control adjustments.

Power Supply

Most electric clutches operate on direct current. If only ac is available, it must be rectified for use with the clutch. If torque control is required for the application, provision must also be made to control the voltage applied to the clutch.

Most clutch manufacturers provide power supplies for their units. However, the clutch power supply may be made an integral part of the entire machine control. Although 90-v dc, obtained by rectifying 110-v ac, is an informal industry standard, most clutches can be wound for special voltages. Several elementary circuits for clutch power supply are shown in Fig. 7.

Space Requirements

Early in the process of selecting a clutch, space requirements should be investigated. Physical size of the clutch and space available for mounting it should be examined. Whether the clutch can be provided with a bore sufficiently large to fit the shaft should also be checked. If a slip-ring clutch is considered, space must be available and in the right location to accommodate brushes and brush holders.

General Installation

After a clutch has been selected on the basis of operational considerations and been given a preliminary dimensional check, any problems that might arise in mounting the clutch in the machine must be resolved. A clutch which provides mounting flexibility allows the designer to select an arrangement best suited to the application.

In most clutches, the normal input side of the clutch is keyed to the shaft. The normal output side in some cases is a gear-type spline or special bushing which takes its drive from the ID of the driven member, and in other cases is a drive cup which takes its drive from the OD of the driven member. The cost and convenience of obtaining and using a particular output member should be considered along with any special machining that might be required to mount the clutch assembly.

If a slip-ring clutch is used, provision must be made for mounting the brushes and brush holders and for insuring that brushes are accessible for maintenance. If one slip ring is mounted on the clutch and the other on the shaft, Fig. 8, care must be exercised in the design to prevent damage to bearings and other machine members. Otherwise, the flow of current through the shaft could lead to arcing with resultant pitting and heating.

If stray magnetism, which is produced in some degree by any clutch, will adversely affect machine operation, the clutch design should be investigated for means of limiting the stray flux. Also, if the clutch exerts any external thrust load, provision must be made to accommodate it.

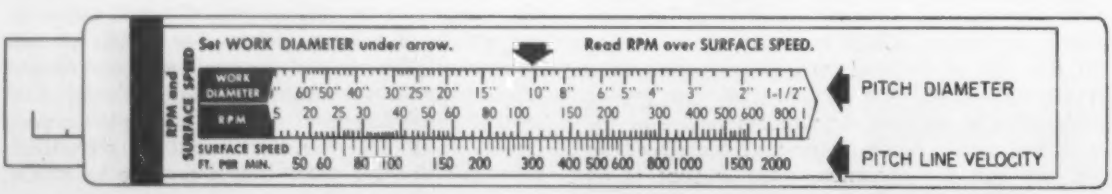
Maintenance

If a clutch is operated at a reasonable temperature, the coil can be expected to last almost indefinitely, particularly if the coil is completely encapsulated in a tough, stable resin. Periodic replacement of friction discs will be required. Frequency of replacement will depend on how hard the clutch is worked, the type of friction material, and the ambient conditions. In general, if a conservatively rated unit is operated in oil, the need for friction-disc replacement will be infrequent. For slip-ring clutches, periodic brush replacement and slip-ring maintenance will be required.

Tips and Techniques

Selecting Drive Components

A cutting-speed calculator, such as those furnished by machine-tool manufacturers, can double as a selector for gears, sheaves, or sprockets. The "Work Diameter" represents pitch diameter, and the "Surface Speed" is pitch-line velocity in fpm.—THEODORE J. POLLARI, *LFM Mfg. Co. Inc., Atchison, Kans.*



VIBRATION ISOLATION DESIGN

A new way to find the forces in the components of a conventional system

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THE classical single-degree-of-freedom system can be used in the design of a vibration isolation system when the mass to be freed of vibrations is supported by a spring and a damper.

Information is plentiful upon the theory and application of the classical method. Comparatively little information is available, however, about dealing with displacement-excited motions — particularly when the loads that are carried by the spring and the damper must be determined.

This article explains the dynamics underlying such determinations and provides curves whereby the dynamic forces can be calculated readily. Examples illustrate the numerical solution of problems.

Vibratory Motion Analysis: The ideal in the design of a vibration isolation mount would be a mass that stays still while the ground or frame vibrates. The next best condition is one in which the vibratory motions of the mass are only a fraction of those of the frame that excites them. This is the condition that prevails in the practical application of vibration isolation.

The components of the conventional system are the frame, the mass, the spring, and the damper, Fig. 1. Usual procedure in vibration analysis regards the frame as rigid. Excitation is applied to the mass. Here, the frame undergoes displacements, s, to provide the excitation.

With viscous damping, the differential equation of motion of mass m is

$$my'' + c(y' - s') + k(y - s) = 0 \qquad (1)$$

Physically, the three terms of Equation 1 represent the inertia force, the damping force, and the spring force, respectively. Rewriting Equation 1 as a function of variable y,

$$my'' + cy' + ky = ks + cs' \qquad (2)$$

If simple harmonic excitation is assumed,

$$s = s_0 \sin \omega t \qquad (3)$$

For this driving function, Equation 2 is satisfied

Nomenclature

A, B = Constants
c = Damping constant, lb-sec per in.
c_c = Critical damping constant, lb-sec per in.
F_D = Damper force, lb
F_s = Spring force, lb
g = Acceleration of gravity, ips^2
k = Spring modulus, lb per in.
m = Mass, lb-sec^2 per in.
s, s', s'' = Frame displacement, in.; velocity, ips; acceleration, ips^2
s_0 = Maximum frame displacement, in.
t = Time, sec
y, y', y'' = Mass displacement, in.; velocity, ips; acceleration, ips^2
y_0 = Maximum mass displacement, in.
ω = Drive circular frequency, rad per sec
ω_n = Natural circular frequency, rad per sec

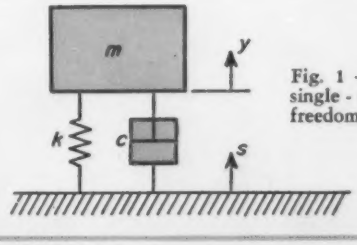

Fig. 1 — Damped single - degree - of-freedom system.

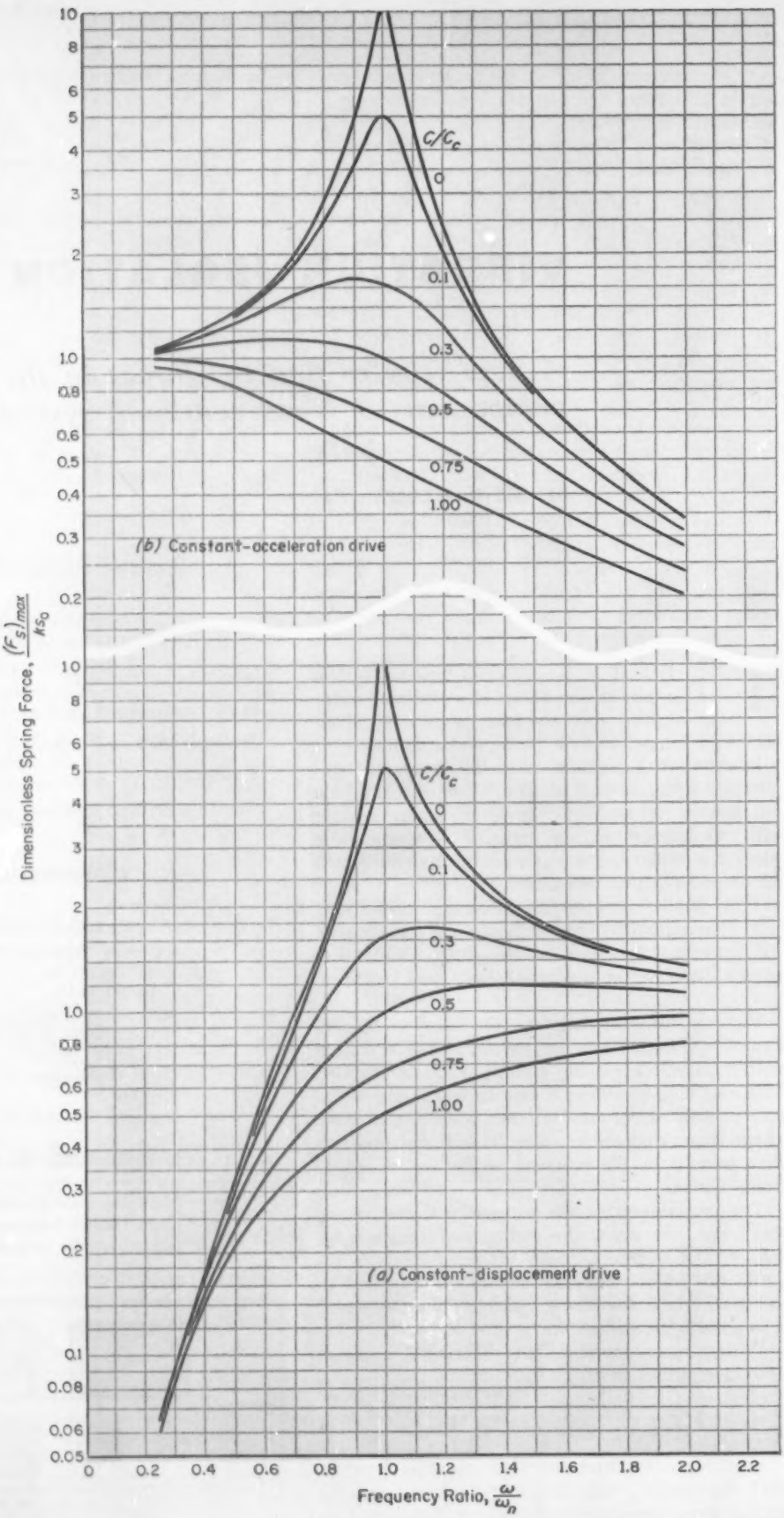

Fig. 2—Maximum spring force versus frequency ratio for various damping ratios.

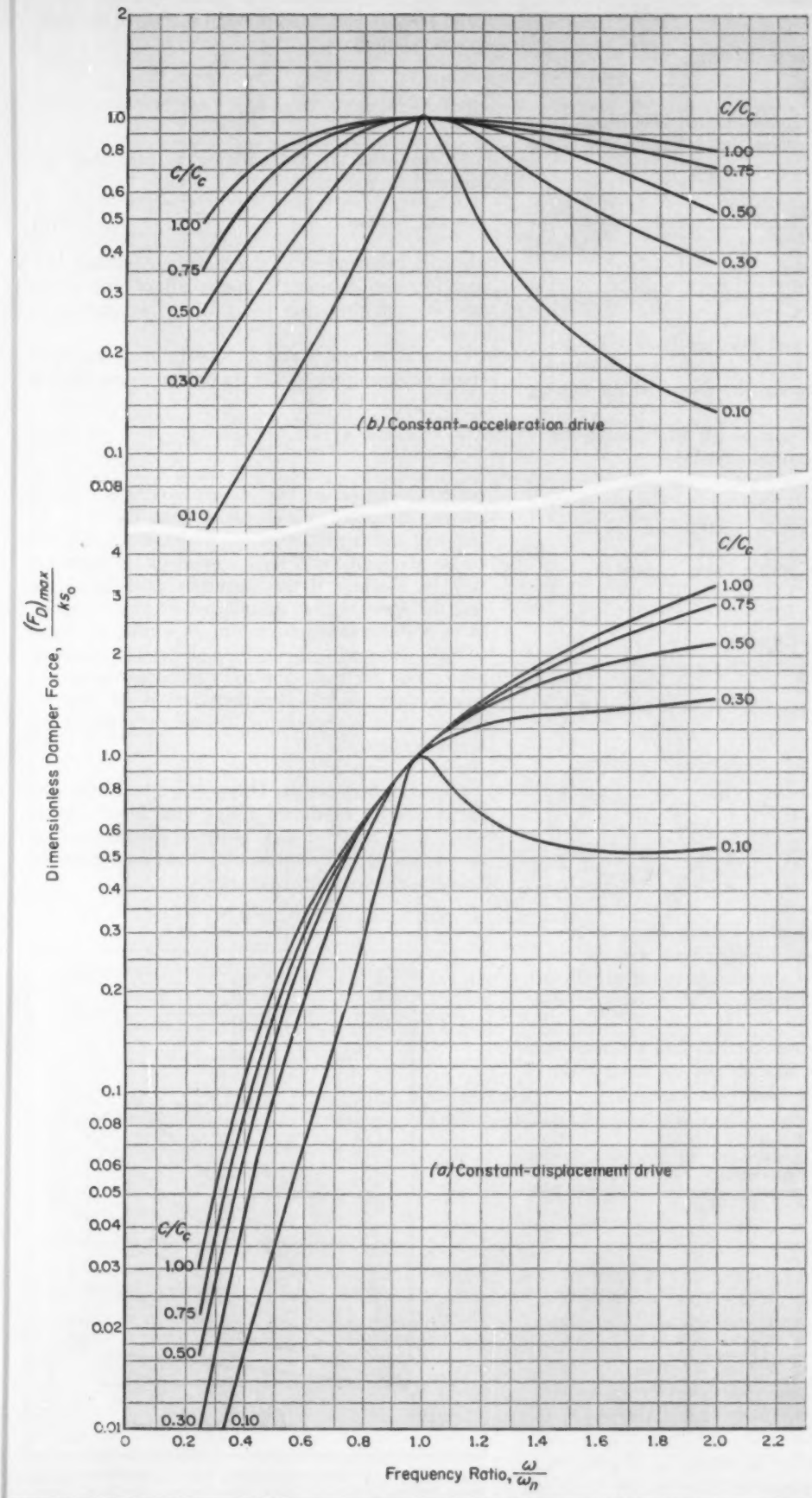
Dimensionless Damper Force, $\frac{(F_D)_{max}}{ks_o}$
Frequency Ratio, $\frac{\omega}{\omega_n}$
(b) Constant-acceleration drive
(a) Constant-displacement drive
C/C_c
1.00
0.75
0.50
0.30
0.10
0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2
2 1.0 0.8 0.6 0.5 0.4 0.3 0.2 0.1 0.08 4 3 2 1.0 0.8 0.6 0.5 0.4 0.3 0.2 0.1 0.08 0.06 0.05 0.04 0.03 0.02 0.01

Fig. 3 — Maximum damper force versus frequency ratio for various damping ratios.

by a particular solution in the form,

$$y = A \sin \omega t + B \cos \omega t \tag{4}$$

where A and B are undetermined coefficients.

If steady-state conditions exist, Equation 4 is the complete solution and

$$A = s_0 \frac{(c\omega)^2 + k(k - m\omega^2)}{(c\omega)^2 + (k - m\omega^2)^2} \tag{5}$$

$$B = -s_0 \frac{mc\omega^3}{(c\omega)^2 + (k - m\omega^2)^2} \tag{6}$$

Maximum Spring and Damper Loads: To determine the maximum spring force, the maximum relative displacement between the mass and the moving frame is found.

From Equations 3, 4, 5, and 6, the absolute value of the maximum frame displacement is

$$| y - s |_{max} = \frac{s_0 m\omega^2}{\sqrt{(c\omega)^2 + (k - m\omega^2)^2}} \tag{7}$$

Thus, the maximum spring force is given by

$$(F_s)_{max} = k \mid y - s \mid_{max}$$

$$= \frac{s_0 k m\omega^2}{\sqrt{(c\omega)^2 + (k - m\omega^2)^2}} \tag{8}$$

In dimensionless form, Equation 8 becomes

$$\frac{(F_s)_{max}}{k s_0} = \tag{9}$$

$$\frac{\left(\frac{\omega}{\omega_n}\right)^2}{2\sqrt{\left(\frac{c}{c_c}\right)^2\left(\frac{\omega}{\omega_n}\right)^2 + \frac{1}{4}\left[1 - \left(\frac{\omega}{\omega_n}\right)^2\right]^2}}$$

Equation 9 is plotted in Fig. 2*a* for s_0 = a constant. If the frequency, damping ratio, and maximum frame displacement of a particular system are known, the maximum spring force can be determined from the curves.

A similar procedure is used to find the maximum damper force. This depends on the magnitude of the maximum relative velocity. In this case,

$$(F_D)_{max} = c \mid y' - s' \mid_{max}$$

$$= \frac{s_0 mc\omega^3}{\sqrt{(c\omega)^2 + (k - m\omega^2)^2}} \tag{10}$$

In dimensionless form,

$$\frac{(F_D)_{max}}{k s_0} = \tag{11}$$

$$\frac{\left(\frac{c}{c_c}\right)\left(\frac{\omega}{\omega_n}\right)^3}{\sqrt{\left(\frac{c}{c_c}\right)^2\left(\frac{\omega}{\omega_n}\right)^2 + \frac{1}{4}\left[1 - \left(\frac{\omega}{\omega_n}\right)^2\right]^2}}$$

which is plotted in Fig. 3*a*. Again, s_0 = a constant. The dimensionless transformations to get Equations 9 and 11 were facilitated through the use of the well-known relations:

$$c_c = 2\sqrt{mk} \qquad \omega_n = \sqrt{\frac{k}{m}} \tag{12}$$

At resonance, it is interesting to note that the damper force reduces to

$$(F_D)_{max} = k s_0 \tag{13}$$

which is independent of the damping constant (except for zero damping); hence, all of the curves pass through the same point for a frequency ratio of unity.

From Equations 9 and 11, the ratio of the maximum damper force to the maximum spring force is

$$\frac{(F_D)_{max}}{(F_s)_{max}} = 2\left(\frac{c}{c_c}\right)\left(\frac{\omega}{\omega_n}\right) \tag{14}$$

which is plotted in Fig. 4. When either force is known, the other can be found from Fig. 4 if the damping and frequency ratios are known. Conversely, the damping ratio for a system under operation may be obtained if the frequency ratio is known and the force ratio is established in some manner, as by suitable instrumentation. As a rule, the logarithmic decrement is used to determine damping ratio. The method, however, is based upon the measurement of free vibrations and is an approximation. It may not apply always to a forced vibratory system.

Constant Acceleration Drive: Fig. 2*b* and 3*b* give the curves for maximum spring and damper forces when the excitation is at constant acceleration, as $s_0'' = s_0\omega^2/g$. Obviously, the drive amplitude decreases with increasing frequency.

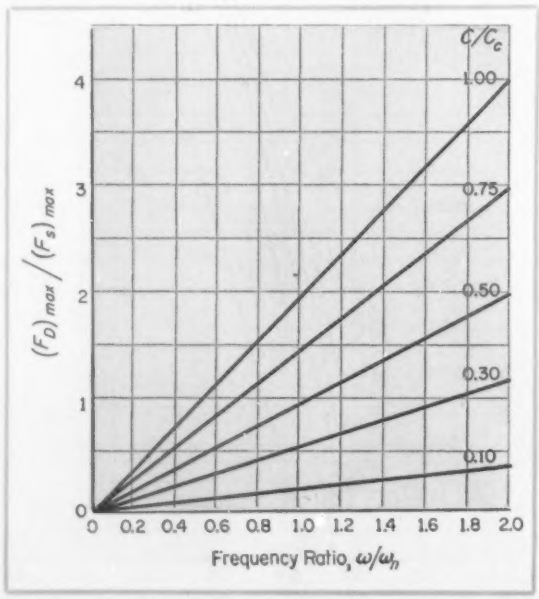

Fig. 4—Ratio of maximum damper force to maximum spring force versus frequency ratio for various damping ratios.

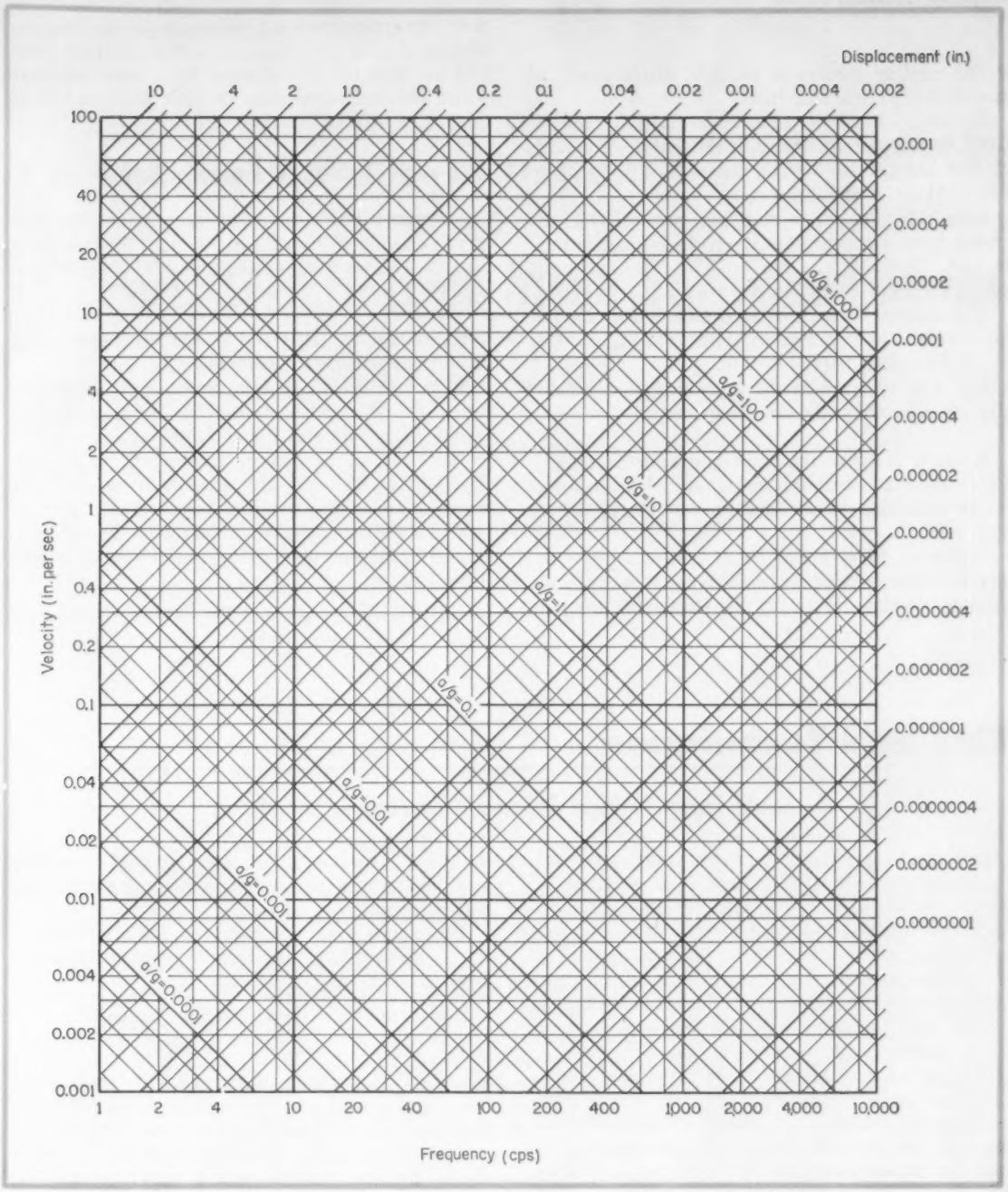

Fig. 5—Vibration nomogram for determining displacement, velocity, acceleration, and frequency for harmonic motion when any two of the parameters are known. (Chart, courtesy Ling Electronics Inc.)

The over-all effect is that the curves of Fig. 2*b* and 3*b* are "flattened" over a greater band width than the curves of Fig. 2*a* and 3*a*. The two sets of curves are assumed to have the same drive amplitude and acceleration at resonance.

Since the frame amplitude does not appear in it, Equation 14 is valid for either constant displacement or constant acceleration drive. Vibration nomograms are available for determining displacement, velocity, acceleration, and frequency for harmonic motion when any two of the parameters are known. Fig. 5 is one of them. Its use is illustrated in conjunction with the solution of problems by the methods of this article.

Example 1: A 3-in. cube of aluminum is supported elastically, Fig. 1. The undamped natural frequency of the system is 50 cps; the maximum exciting frequency is 100 cps. Assume a damping ratio of 0.3. Calculate the maximum spring and damper forces

if the exciting motion is constant displacement of $s_0 = 0.04$ in., single amplitude.

SOLUTION: Mass of cube, $m = 0.1\,(3)^3/386 = 0.007$ lb-sec^2 per in. Natural frequency, $\omega_n = 2\pi f_n = 314$ rad per sec. Spring constant, $k = m\omega_n^2 = 0.007\,(314)^2 = 690$ lb per in.

From Fig. 2*a*, for a damping ratio of 0.3, the spring force is a maximum when the frequency ratio is 1.13. Thus, $(F_s)_{max}/ks_0 = 1.70$. The maximum spring force is 1.70 (690) 0.04 = 47.0 lb.

The damper force is a maximum when the frequency ratio is 2.00, Fig. 3*a*. Thus, $(F_D)_{max} = 1.45\,ks_0 = 1.45\,(690)\,0.04 = 40.0$ lb.

Fig. 4 is not used in the last calculation because the forces are not at the same frequency.

Example 2: Given the same data as in Example 1. Calculate the maximum spring and damper forces if the excitation is constant acceleration of $s_0'' = 10g$.

SOLUTION: From Fig. 5 at 50 cps, $s_0 = 0.04$ in., which merely happens to be the same value as in the previous example. From Fig. 2*b*, for the 0.3 damping ratio, the spring force is a maximum for the frequency ratio of 0.93. Or, $(F_s)_{max} = 1.70\,ks_0 = 1.70\,(690)\,0.04 = 47.0$ lb. The damper force is a maximum when the frequency ratio is 1.00, Fig. 3*b*. Thus, $(F_D)_{max} = 1.00\,(690)\,0.04 = 27.6$ lb.

Example 3: Same as Example 2 except for $s_0'' = 20g$.

SOLUTION: The $s_0 = 0.08$, the resonant displacement. $\omega/\omega_n = 0.93$. $(F_s)_{max} = 1.70\,(690)\,0.08 = 94.0$ lb. $\omega/\omega_n = 1.00$. $(F_D)_{max} = 1.00\,(690)\,0.08 = 55.2$ lb.

Example 4: What would be the maximum spring force at resonance in Examples 1, 2, and 3?

SOLUTION: From Fig. 4, for frequency and damping ratios of 1.00 and 0.3, respectively, $(F_D)_{max}/(F_s)_{max} = 0.6$. For Examples 1 and 2, $(F_s)_{max} = 27.6/0.6 = 46.0$ lb. In the case of Example 3, $(F_s)_{max} = 55.2/0.6 = 92.0$ lb. The agreement between the resonant (maximum) spring force values in the last problem with the maximum values for Examples 1, 2, and 3, in general, is fairly good for small damping values.

Tips and Techniques

Calculating Thermal Expansion of Tapered Members

In most designs combining parts made of two different materials, the engagement is at a cylindrical surface. However, within a given envelope, a tapered engagement distributes forces over larger areas, thus minimizing stress levels. The intimate contact at the tapered surfaces, if retained throughout the operating-temperature range, contributes a shakeproof quality that is particularly desirable in a vibrating environment.

For instance, a tapered metal stud and plastic block are usually assembled with zero radial clearance at the taper. Ideally, the increment of clearance due to temperature rise will also be zero. An increase in clearance lessens vibration resistance; interference increases the compression-stress level in the block. Factors other than thermal expansion may also govern the design, and some compromise may be necessary.

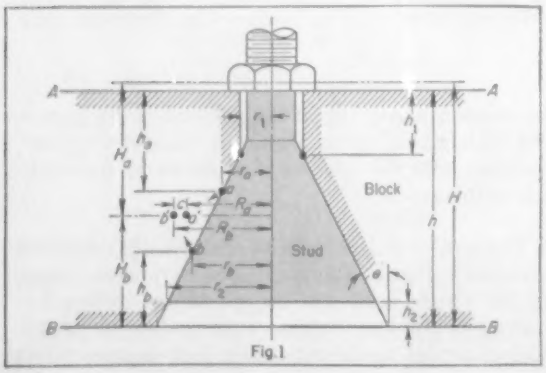

Fig. 1

The equation for the clearance (or interference), c, of corresponding points on the two tapered surfaces is:

$$c = [(1 + \alpha_b \Delta t)(r_2 - h \tan\theta + h_2 \tan\theta) - (1 + \alpha_a \Delta t)(r_1 - h_1 \tan\theta)]$$

where Δt = temperature change from assembly to operation; α_a and α_b = thermal coefficients of linear expansion for stud and block materials respectively; and r_1, r_2, h, h_1, h_2 and θ are physical dimensions shown in Fig. 1. Subscripts a refer to points on the surface of the stud; b, to points on the surface of the block. Dimensions at room temperature are in lower case letters and those at elevated temperatures in capitals.

Axial expansion of the stud is measured downward from line *AA* and the block's axial expansion, upward from line *BB*.

Point a on the stud moves, with rise of temperature, to some point a', point b on the block, to b'. The original locations a and b are located so that a' and b' are on a discrete radial line.

If the solution for c yields a negative quantity, expansion has caused an interference fit. The equation is a general expression and is applicable to any combination of materials.—GEORGE H. LOGAN, *North American Aviation Inc., Los Angeles, Calif.*

Thermal Stresses in Design

Part 21—Effect of Mean Stress and Strain on Cyclic Life

- **Stress Components**
- **Multiaxiality**
- **Prestrain in Plastic Range**

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EACH region of a body subjected to repetitive cyclic temperature may undergo a complex history of stress and strain. But, after a sufficiently large number of such cycles, the conditions at any one point tend to stabilize and assume a repetitive pattern.

Usually, the life is sufficiently long to be governed largely by the repetitive pattern that is established rather than by the early cycles. But, the early cycles are also of importance since they influence the shakedown condition that is established. They may also result in permanent material prestrains which influence the resistance to subsequent cycling. This article discusses the estimation of cyclic life in parts which have been subjected to tensile prestrain. Such situations are very common when external loads are superimposed on the loads developed by the thermal cycling. But, they may also occur when the loads are entirely thermal.

The effect of tensile prestrain is illustrated by two important cases. Fig. 126, which is essentially the same as Fig. 125,[20] shows the shakedown condition for the two members of a constrained two-bar structure, one bar of which is subjected to cyclic temperature variations. The structure is required to support external load L. Upon shakedown, the lighter bar, A, of the two bars develops a cyclic plastic strain while alternating between tensile and compressive stress of approximately equal magnitude. While the effect on life of cyclic plastic or total strain has been discussed,[20] an important distinction here is that the material is subjected to a large mean strain, $\frac{1}{2}(\varepsilon_{A,n} + \varepsilon_{A,n+\frac{1}{2}})$, before commencing the period in which only cyclic strain $(\varepsilon_{A,n+\frac{1}{2}} - \varepsilon_{A,n})$ is im-

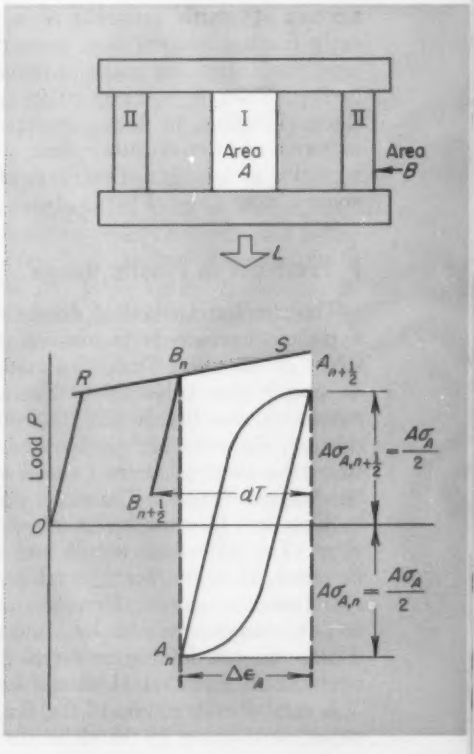

Fig. 126—Load-strain relations asymptotically approached in two-bar structure supporting external load, while one bar is thermally cycled. Condition of bar A not determined from initial load-strain curve of the material.

[20]References are tabulated at end of article.

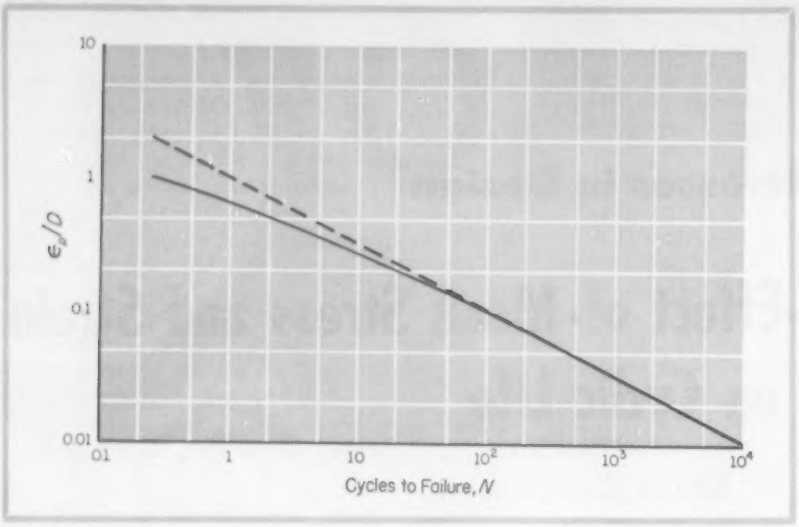

Fig. 127—General shape of ϵ_p versus N curve for cycling from zero to maximum strain.

posed. It is important, therefore, to determine the effect of plastic prestrain on life under known cyclic strain. This leads to a better understanding of the method for determining the constants in the life equation, Equation 11.[3]

The other important effect of prestrain on life is illustrated in Fig. 126 by bar B. Here a certain amount of plastic prestrain is induced during the early loading history. But, once the prestrain has been established, the material settles down to elastic cycling. Since it is common, in dealing with mechanical fatigue, to define the operating conditions in terms of stresses rather than strains, bar B can be said to cycle with a stress range of $(\sigma_{B,n} - \sigma_{B,n+1/2})$ about a mean stress of $\frac{1}{2}(\sigma_{B,n} + \sigma_{B,n+1/2})$.

Prestrain in Plastic Range

The simplest method of determining the effect of a plastic prestrain is to observe the effect of prestrain on ductility. Thus, if a material has ductility D, and is first subjected to plastic prestrain δ, its remaining ductility is $(D - \delta)$. Hence, if the life relation, Equation 11,[3] is rewritten in terms of ductility, the effect of altering the ductility on life can be deduced directly. Therefore, constants K and n in Equation 11 must be expressed in terms of ductility. The values of $n = 2$ and $K = D^2/4$, from Equation 11 with $N = 1/4$ and plastic strain D, is often assumed correct. However, a good correlation is not always obtained by choosing $K = D^2/4$. Thus, the relationship between ductility and the constants in Equation 11 should be re-examined.

A careful examination of the shape of the $\epsilon_p - N$ curve, particularly in the vicinity of very low values of N has been made.[21,22] In general, if the tensile test is regarded as a cyclic test with $N = 1/4$, the log-log curve of ϵ_p and N is not a straight line in the low cycle range, Fig. 127. Although quite straight, as required by Equation 11, at numbers of cycles more than 10, the curve bends down progressively at lower cycle region. The intercept of the extrapolated straight portion of the curve on the line $N = 1/4$ has a numerical value approximately twice the ductility, rather than simply equal to the ductility. Hence it would appear that either Equation 11 is invalid at low values of N or that consideration must be given to some other factor at the low values of N.

The difficulty can be resolved if a more precise definition is given of the conditions under which the life equation is expected to be valid. Since cyclic life might be expected to have some dependence on mean strain as well as cyclic plastic strain, Equation 11 can at best be valid only if the mean strain is zero. Thus, tests to ascertain the validity of this equation should be conducted with zero mean strain, Fig. 128. The test specimen, after being strained a given amount in tension, was caused to flow an equal amount in compression before the cycle was repeated. If the tensile test is to be regarded as one-quarter cycle of a reversed-loading test in which the mean strain is zero, Fig. 128, the plastic strain for the complete cycle must be twice the ductility. Hence Equation 11 becomes

$$N = \frac{1}{4}(\epsilon_p/2D)^n \qquad (175)$$

For $n = 2$, Equation 175 becomes

$$N = \left(\frac{D}{\epsilon_p}\right)^2 \qquad (176)$$

Now, if plastic prestrain δ is imposed on the material prior to strain cycling, the ductility becomes $(D - \delta)$, and the equation for the remaining life is

$$N = \frac{1}{4}\left[\frac{2(D-\delta)}{\epsilon_p}\right]^n \qquad (177)$$

Or, for $n = 2$,

$$N = \left[\frac{(D-\delta)}{\epsilon_p}\right]^2 \qquad (178)$$

Equations 177 and 178 then replace Equation 11 for determining life. Of course, both D and δ must

be measured as true, or logarithmic strains.

Validity: The nonlinearity of the $\varepsilon_p - N$ curve has been used to validate Equation 178. This nonlinearity exists largely because most tests used to determine the validity of Equation 11 were not conducted under the condition of zero mean strain, Fig. 128. The more conventional procedure is to stretch a material to a given length, and then to return it to its original length, rather than to cause it to become correspondingly shorter than the original length as required by Fig. 128. If a series of tests are run with different strain ranges, each test then has a different prestrain, Fig. 129. The actual test consists of successively traversing the path *OAB* in the first half cycle, and *O'ABCDE* in the remainder of the test. Some allowance must, of course, be made for the change in the hysteresis loop developing during the cycling as previously discussed.

Approximately the same results would be obtained if, in the first cycle, the straining were stopped at *A*, unloaded to *A'* and then resumed along the dotted line *A'B*. Continued cycling, after the first cycle, would still occur along *O'ABCDEO'*. Hence, this test is then equivalent to first applying a prestrain of approximately $\varepsilon_p/2$, and then applying a plastic-strain range, ε_p, about a reference point *A'*. Thus, from Equation 178,

$$N = \left(\frac{D - \frac{\varepsilon_p}{2}}{\varepsilon_p} \right)^2 \qquad (179)$$

The log-log plot of ε_p versus N is no longer a straight line, but is curved, Fig. 127. After approximately 10 cycles, the curve straightens out, and assumes a slope of $-1/2$. But in the region to 10 cycles, a distinct downward curvature occurs.

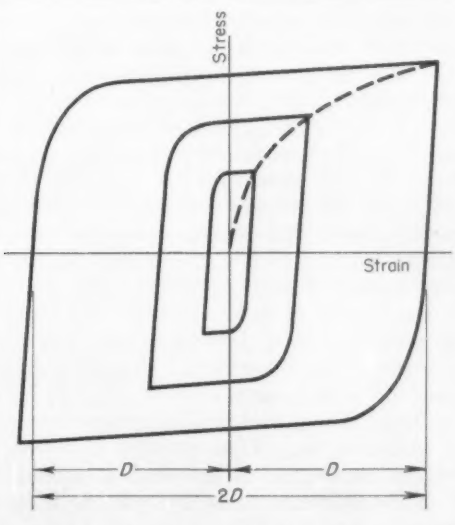

Fig. 128—Stress-strain relations for specimens cycled with different strain amplitudes but at zero mean strain. The tensile test corresponds to a plastic strain of 2*D* at $N = 1/4$.

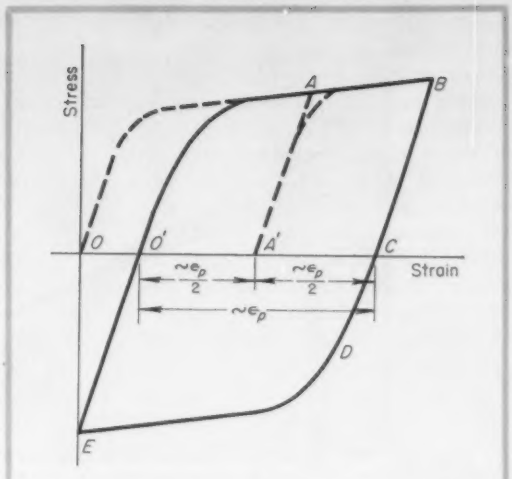

Fig. 129—Stress-strain relation for strain cycling involving return to original length. Mean strain is half the plastic-strain range.

Fig. 130 shows the behavior of ε_p and N for different values of δ when δ is linearly related to ε_p. The higher the value of δ/ε_p, the greater is the deviation from linearity in the low cycle range. For large values of N, larger than 100, the effect of δ becomes relatively small. When δ is constant, rather than proportional to ε_p, the ε_p to N relation is a straight line intersecting the value $N = 1$ at $\varepsilon_p = (D - \delta)$.

Application: Equation 176 is usually used to predict cyclic life in applications such as bar *A*, Fig. 125,[20] where a substantial prestrain is imposed before commencement of cyclic straining. The derivation presented here also has other value: It explains in part the curvature of the ε_p to N relation at the low number of cycles, and it provides an indication of how the tensile ductility helps predict the ε_p to N behavior at higher cyclic lives. For example, the curve for ε_p versus N, Fig. 130, is sensitive to δ and therefore to the mode of applying the strain cycling for the relatively low number of cycles. The solid line drawn through point $\varepsilon_p = 2D$ at $N = 1/4$ and having a slope of $-1/2$ not only represents the material behavior well over the entire range of N for $\delta = 0$, but it also represents the curves for other values of δ/ε_p for the large number of cycles to failure. Thus, the equation $N = (D/\varepsilon_p)^2$ will give reasonably good values of N as long as N is appreciably large (> 100) regardless of the relation between prestrain and plastic strain per cycle. The ε_p to N relation for the conventional test, in which the strain is cycled between zero and a fixed strain limit, can thus be estimated by drawing a line of slope $-1/2$ through the point $\varepsilon_p = 2D$, $N = 1/4$.

Although exponent n in Equation 11 is usually close to 2, appreciable deviation from this value can occur for some materials. For most of these materials, the ε_p versus N curves tend to be a little

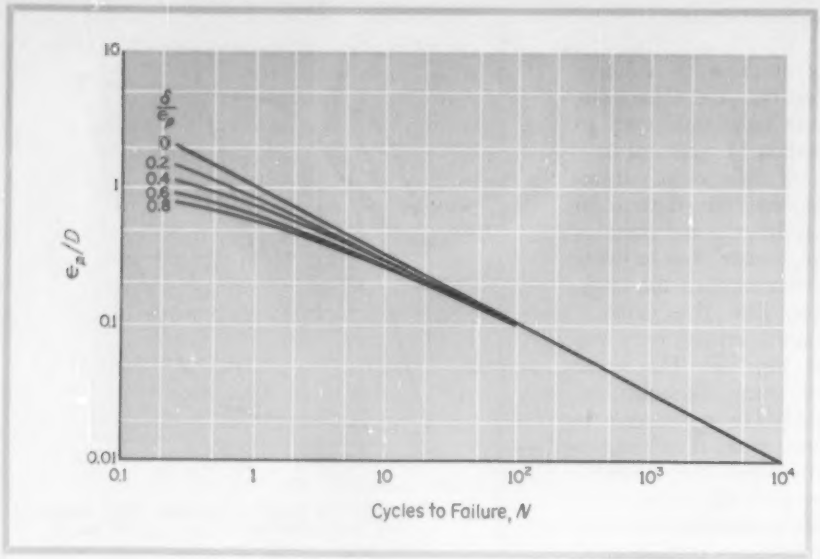

Fig. 130 — General appearance of ϵ_p to N relation for prestrains which are dependent on the plastic strain.

steeper than that required by $n = 2$. If an attempt is made to approximate this curve by a line with $n = 2$, it is usually best to pass the line through a point having an ordinate lower than $2D$ at the abscissa $N = 1/4$. A reasonable compromise that appears valid for the range of materials examined is to choose this ordinate at $1.5D$. It is for this reason that the compromise Equation 154[19] assumes the form shown.

Effect of Multiaxiality

The discussion thus far has dealt with uniaxial strain. When biaxial or triaxial strains are involved, some method must be postulated to combine their effect into a single formula. Also it is necessary to indicate a procedure for separating plastic strains from total strains, so that Equation 176, which involves only plastic strains, can be applied.

Let it be assumed that *total* strain components ϵ_x, ϵ_y, ϵ_z have been determined either by measurement or by computation at two extreme conditions, 1 and 2, and that these total strains therefore fluctuate between $\epsilon_{x,1}$, $\epsilon_{y,1}$, $\epsilon_{z,1}$ and $\epsilon_{x,2}$, $\epsilon_{y,2}$, $\epsilon_{z,2}$. A simple procedure, as yet of unknown validity, but consistent with other engineering approaches used in such situations, is as follows:

1. Separate strains in each direction into mean and alternating components ϵ_m and ϵ_a respectively. Thus $\epsilon_{x,m} = \frac{1}{2}(\epsilon_{x,1} + \epsilon_{x,2})$ and $\epsilon_{x,a} = (\epsilon_{x,1} - \epsilon_{x,2})$, with similar relations for the strain components in the y and z directions.
2. Combine mean components $\epsilon_{x,m}$, $\epsilon_{y,m}$, $\epsilon_{z,m}$ into an equivalent total mean strain, ϵ_m, according to equation 80.[11] Then apply Equation 81,[11] together with the stress-strain curve, to determine the plastic component of ϵ_m, which can be designated as $\epsilon_{p,m}$. This plastic component takes the place of δ in Equation 177.
3. Follow a procedure similar to step 2, using the alternating components $\epsilon_{x,a}$, etc., to determine an equivalent component of plastic alternating strain, $\epsilon_{p,a}$. This quantity takes the place of ϵ_p in Equation 176.

The foregoing procedure does not take into account the effect of multiaxiality in the ductility of the material. Little experimental information is available on this effect. Where known, the ductility can, of course, be altered to account for the reduction.

Mean and Alternating Stress Components

In many problems it is not convenient to compute the plastic strains involved, and it is much easier to work with the stress components. This is particularly true if a portion of the loading is mechanically imposed. Analysis on a stress basis is also desirable when the nominal stresses are in the elastic range, thus implying infinite life, whereas fatigue tests in this stress range indicate finite life. Undoubtedly, in such cases, the plastic flow involved is highly localized, and does not show up in an engineering analysis. But, it is nevertheless present to reduce experimental life.

Basis: For this purpose, use is made of a modified Goodman diagram shown on the right side of Fig. 131, in which the co-ordinates are mean stress and alternating stress. This provides curves of constant life. Hence, any point on a given curve will provide one combination of mean and alternating stress for which the number of cycles to failure will be equal to the parametric value associated with that curve. For example, if the curve for infinite life is desired, one point on such a curve must be point B, having a mean stress of zero, and an alternating stress equal to the endurance limit. Likewise point O, having an alternating stress equal to zero and a mean stress equal to the ultimate tensile strength, must lie on this curve.

The line between O and B will in general be curved. But, in the absence of adequate experimental information for a given material, it can be assumed as a first approximation that the straight line OAB is the locus of combinations of σ_{alt} and σ_{mean} that will

give infinite life.

At $\sigma_m = 0$, the locus of combinations of mean and alternating stresses must pass through B', the ordinate being determined from the conventional fatigue curve to the left of the figure for stipulated life N_1. This curve must also approach the horizontal axis in the vicinity of point O, since any steady stress less than σ_u gives infinite life, whereas any steady stress greater than σ_u gives essentially zero life. Again if the curve is approximated by a straight line, the locus of combinations which yield cyclic life N_1 is the straight line joining the readily determinable points B' and O.

Procedure: To determine the life associated with the point A' having a mean and alternating stress $\sigma_{m,A}'$ and $\sigma_{a,A}'$, respectively, the procedure becomes: 1. Plot A' having the known co-ordinate. 2. Join O to A'. 3. Extend the straight line until it intersects the vertical axis at B'. 4. Determine N_1 from the ε to N curve corresponding to the alternating stress σ_B'.

Instead of the stress at O equal to the ultimate tensile strength, the mean between the yield stress and the ultimate tensile strength can be used.[24]

In constructing the ε to N curve to the left of Fig. 131, it is naturally desirable to use experimental fatigue data for the material. When plotting such data, the vertical stress scale is linear, whereas the ε to N curve is frequently plotted on log-log co-ordinates. When information on the fatigue characteristics of a material is limited, use can be made of a commonly used approximation.[25] A reasonable approximation of the ε versus N curve can be obtained by constructing a straight line on log-log co-ordinates between 0.90 σ_u at 10^3 cycles and σ_E at 10^6, where σ_u and σ_E are the ultimate strength and endurance limit, respectively. Such a construction can be performed on an auxiliary plot, and transferred to Fig. 131 which uses semilog co-ordinates. Alternatively, it is possible to provide a transfer scale to proceed from linear to logarithmic co-ordinates. This procedure is used in a later example, Fig. 132.

It is also possible to apply the foregoing principles of geometric construction, together with the approximations indicated, to arrive at the formulas for the number of cycles to failure corresponding to a mean and alternating stress. This formula is valuable when only the ultimate tensile strength, yield strength, and endurance limit are known. If σ_O is the stress at the point O, Fig. 131, the number of cycles to failure is

$$\log_{10} N = \frac{3 \log_{10} \left(\frac{\sigma_a \sigma_E}{0.81 \sigma_u^2} \right) \left(\frac{\sigma_o}{\sigma_o - \sigma_m} \right)}{\log_{10} \left(\frac{\sigma_E}{0.9 \sigma_u} \right)} \quad (180)$$

If the point O is taken at the ultimate tensile strength, at the yield point and at the mean of the two stresses, then $\sigma_O = \frac{1}{2}(\sigma_u + \sigma_y)$.

Effect of Stress Concentration: Presence of a stress concentration in the form of a discontinuity of geometry or material property can seriously reduce the fatigue life of a test specimen or a machine structure. In conventional design for mechanical fatigue, it is common to compute the stresses as if no concentration factor were present, and then to correct fully for the alternating component of stress through multiplication by the effective stress-concentration factor. The nominal steady component of stress, or mean stress, is usually treated without correction.

Application of the above rule involving multiplication of the alternating component of stress by the effective stress concentration runs into some difficulty, since the effective stress concentration depends on the life, and is therefore unknown until the life is determined. This difficulty can be overcome by resorting to a trial and error procedure. But fortunately, it is possible to avoid such a procedure by using a simple geometric relationship shown in Fig. 132.

While the theoretical stress-concentration factor for a given geometry can be calculated by conventional elasticity procedures, the full value of this theoretical stress-concentration factor does not appear to be active in reducing the life. Consider two specimens, one smooth and one notched, which have the same theoretical elastic stress. The notched specimen achieves this stress at the root of the notch as a result of the influence of a stress-concentration factor acting on a low nominal stress, while the smooth specimen is subjected directly to the stress. In general, the notched specimen has a longer life than the smooth one. For this reason, the effective stress-concentration factor is introduced, Fig. 132. Let P represent the σ versus N curve of the material for the smooth specimen, and Q the σ versus N curve for the notched bar. The ordinate stresses in both cases are nominal values, without regard for the stress concentration. The ratio, $k'_{N,1} = \sigma_B'/\sigma_A'$, which produces the same cyclic life, N_1, is defined as the effective stress-concentration factor. In general, $k'_{N,1}$ is less than the theoretical geometric stress-

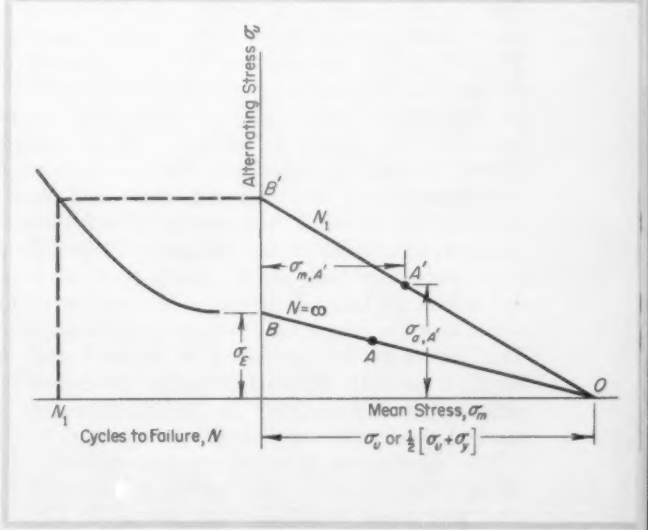

Fig. 131—Procedure for determining cyclic life in material subjected to alternating stress superimposed on a mean stress.

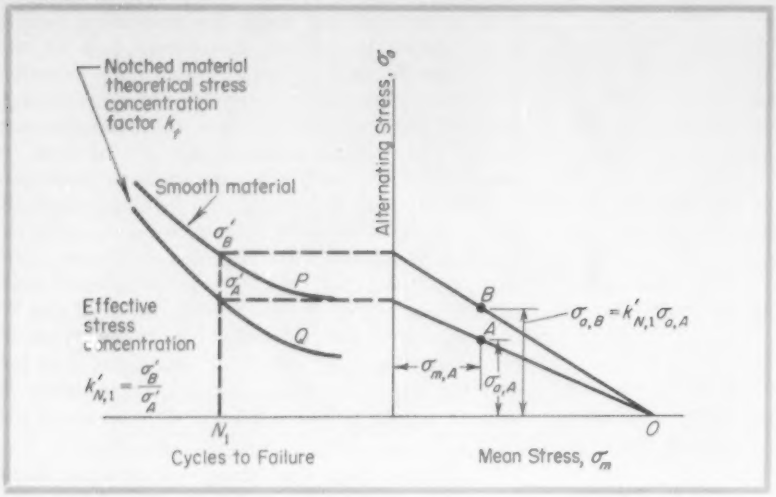

Fig. 132—Method of accounting for notch having theoretical stress-concentration factor k.

concentration factor, k_t. Although the curves P and Q are schematic in Fig. 132, the geometric relation shown is typical of actual curves.

Hence, to estimate life, point A is located. This point has the known component of mean and alternating stresses, $\sigma_{m,A}$ and $\sigma_{a,A}$ without allowance for stress concentration. Then point B having the coordinates ($\sigma_{m,A}$, $k'_{N,1}$ $\sigma_{a,A}$) is located. But, $k'_{N,1}$ is not known. If B could be determined, the line OB would be extended to intersect the vertical axis at σ_B'. The point on the σ versus N curve for the smooth specimen having the ordinate σ_B' would then be located by projection, and the life N_1 determined. However, exactly the same result would be obtained by joining O to the *known* point A, extending the line to σ_A' on the vertical axis, and then projecting to the point on the σ—N curve of the *notched* material having the ordinate σ_A'.

Thus the point B and the σ—N curve for the *smooth* material need not even be introduced into the problem. The procedure is simply to locate A, then σ_A', and then to determine life for the value of σ_A' from the σ—N curve of the *notched* material. This, of course, assumes that fatigue properties of the notched material are experimentally determined. For preliminary design, such properties may not be available. But, it may be desirable still to estimate the life in gross approximation. For this purpose, it may be assumed that the full theoretical stress-concentration factor, k, becomes the effective stress-concentration factor at the endurance limit. Thus, if the endurance limit of the smooth material is σ_E, the endurance limit of the notch material is σ_E/k_t, where k_t is the theoretical stress-concentration factor. The procedure for analyzing a notched part is identical to that for analyzing the corresponding smooth part, except that the σ—N curve for a notched specimen is used in the former case.

The significance of mean stress in affecting the life of a part under thermal cycling is illustrated by tests performed on notched specimens of Timken Alloy 16-25-6.[26]

An important observation drawn from these tests shows that for the same alternating stress, a seventy-fold reduction in life occurred when the sign of the mean stress was changed while its magnitude was maintained approximately constant. The graphical construction would have predicted a life reduction factor of approximately 54. The importance of mean stress cannot be overestimated for cases in which the operating stresses are nominally elastic. The order of application of thermal load, which governs the mean stress, can thus be of the greatest importance in determining cyclic life of a structure.

Application: The foregoing procedure can be directly applied to thermal-stress problems by application of the elastic strain-invariance principle. The calculations can, at best, be regarded only as engineering approximations, since the elastic strain-invariance principle, the σ—N curve, and particularly the concept of effective stress-concentration factor, are all approximations which neglect true localized conditions. But, the availability of even rough indications of cyclic life may be valuable in initial design, and for comparison of several alternative designs.

To apply the elastic strain-invariance principle, the procedure is simply to compute all the strain components on the assumption that the material remains elastic. Once these strains are known from elasticity, they are assumed to be the correct strains even under the condition of plastic flow, and a preliminary problem must first be solved to determine what the stress components need to be if the strain components are to be those calculated from plasticity. The basis for such calculations has already been described.[11] The equivalent total strain, $\epsilon_{e,t}$, can then be computed, and from this strain, together with the stress-strain curve, the equivalent plastic strain, $\epsilon_{e,p}$, can be computed.[11] Equations can then be used to obtain the plastic components of strain.[11] From the total strains and plastic-strain components, equations can be used to compute the stress components. This procedure is repeated at each of the extreme conditions of operation, some-

times requiring several trial calculations to determine the extreme conditions on which to base design.

For purposes of further analysis it will be assumed that each critical point in the structure has been analyzed, and that the stress components have been determined at the two extremes on which the design is to be based. Since in the design of symmetrical components the directions of the principal stresses are known, it will be assumed that the directions involved are the principal directions. The first step is to separate the stress variation in each of the directions into a mean and an alternating component. In the x direction, for example,

$$\sigma_{x,m} = \frac{\sigma_{x,1} + \sigma_{x,2}}{2} \qquad \sigma_{x,a} = \frac{\sigma_{x,2} - \sigma_{x,1}}{2} \qquad (181)$$

The second step is to determine an equivalent mean stress, $\sigma_{e,m}$, based on the components of mean stress, and an equivalent alternating stress, $\sigma_{e,a}$, based on the components of the alternating stress. From Equation 74,[11]

$$\sigma_{e,m} = \pm \frac{1}{\sqrt{2}} [(\sigma_{x,m} - \sigma_{y,m})^2 + (\sigma_{x,m} - \sigma_{z,m})^2 + (\sigma_{y,m} - \sigma_{z,m})^2]^{1/2} \qquad (182)$$

and

$$\sigma_{e,a} = \pm \frac{1}{\sqrt{2}} [(\sigma_{x,a} - \sigma_{y,a})^2 + (\sigma_{x,a} - \sigma_{z,a})^2 + (\sigma_{y,a} - \sigma_{z,a})^2]^{1/2} \qquad (183)$$

A question arises, however, as to the algebraic sign of $\sigma_{e,m}$. This sign may be taken as that of the largest of the components $\sigma_{x,m}$, $\sigma_{y,m}$ or $\sigma_{z,m}$. Beyond this point the problem can be treated essentially as a uniaxial case, in which the mean stress is $\sigma_{e,m}$ and the alternating stress $\sigma_{e,a}$.

The foregoing method for analyzing cases involving triaxial stresses in which the components have nonzero mean values is only one of the many methods that can be used.[28]

The next article in this series will discuss the cumulative damage caused by cycling.

References

This article is the twenty-first in a series by S. S. Manson on thermal stresses in design. Earlier parts appeared in the following issues of Machine Design.

1. June 12, 1958
2. June 26, 1958
3. Aug. 7, 1958
4. Aug. 21, 1958
5. Sept. 4, 1958
6. Jan. 22, 1959
7. Feb. 5, 1959
8. Feb. 19, 1959
9. Mar. 5, 1959
10. Mar. 19, 1959
11. July 9, 1959
12. July 23, 1959
13. Aug. 6, 1959
14. Oct. 29, 1959
15. Nov. 12, 1959
16. Nov. 26, 1959
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19. July 7, 1960
20. July 21, 1960

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21. G. Sachs and A. D. Taber—"Relations Governing Low Cycle Fatigue— A Summary of the Pertinent Literature," University of Syracuse, Report No. MET575-58511, May 1958.
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24. B. F. Langer—"Design Values for Thermal Stress in Ductile Materials," ASME Paper No. 58-MET-1, 1958.
25. Louis S. Clock—"Analysis of Fatigue Strength, Machine Design Vol. 31, Oct. 15, 1959, p. 167.
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Tips and Techniques

Circle Formulas

These formulas for parts of circles permit solution for unknowns with various combinations of known values. Fig. 1 identifies dimensions and angles used in the tabulated formulas. — A. D. Roberts and W. D. Carroll, *Diamond Match Div., Diamond National Corp., Barberton, Ohio.*

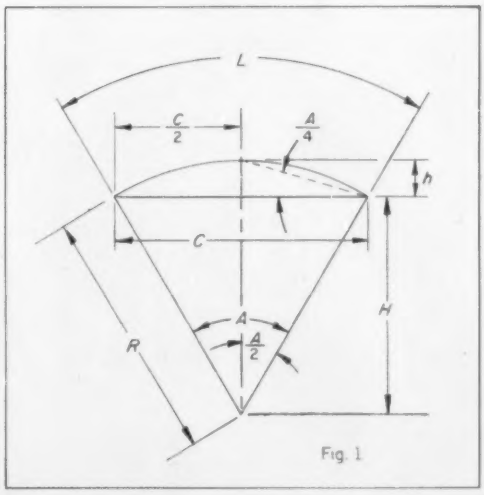
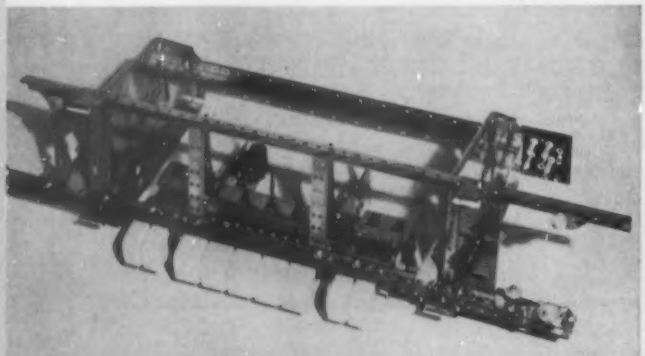


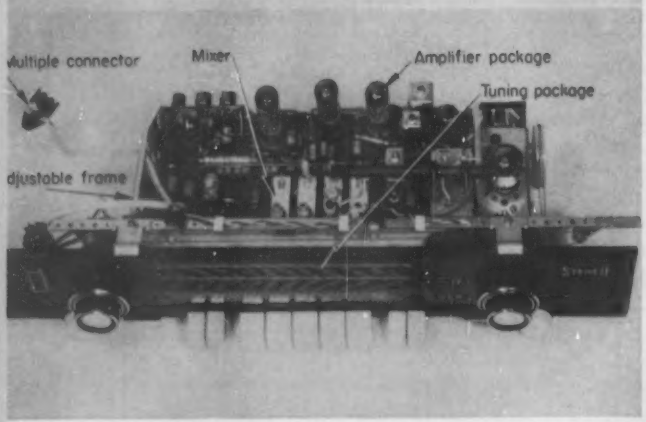
Fig. 1

Unknown	Known	Formula
A	C and R	$\sin(A/2) = C/2R$
	C and H	$\tan(A/2) = C/2H$
	C and h	$\tan(A/4) = 2h/C$
	L and R	$A = 2\pi R/L$
C	A and R	$C = 2R\sin(A/2)$
	A and L	$C = \frac{360L\sin(A/2)}{\pi A}$
	L and R	$C = 2R\sin[28.6478L/R]$
H	R and A	$H = R[1 - \cos(A/2)]$
	R and C	$H = R - [R^2 - (C/2)^2]^{1/2}$
L	A and R	$L = \pi RA/180$
	A and C	$L = \frac{0.008726CA}{\sin(A/2)}$
R	A and L	$R = 180L/\pi A$
	A and C	$R = \frac{C}{2\sin(A/2)}$

Packaged-Component Design Makes Radio Servicing a Cinch

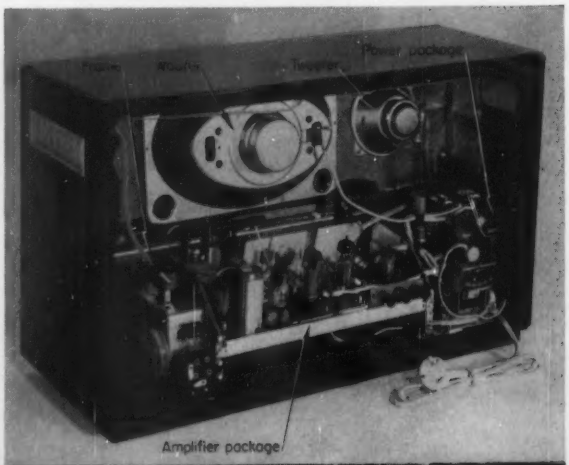
COMPONENTS ARE PACKAGED in subassemblies for quick replacement in a new table radio. For manufacturing economy, packages are designed to be interchangeable with those of other models in the company's line. Expandable mounting frame can be adapted to a variety of cabinet sizes and shapes. Multiple connectors save time-consuming circuit tracing and possible connecting errors. Exception to the interchangeability rule is the tuning package which varies in size and shape according to cabinet style and number of tuning bands.

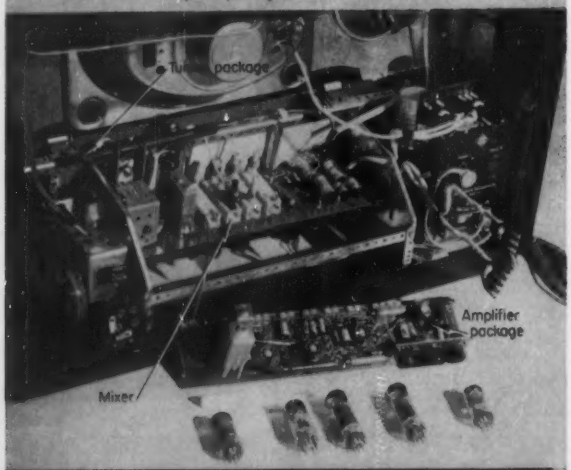


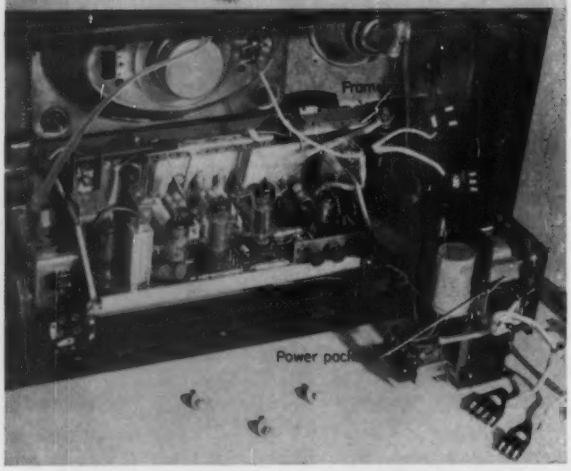


TROUBLE SOURCES ARE ISOLATED in four packages: Power package, tuning package, mixer, and amplifier package. Each of these can be quickly removed and replaced by a semiskilled worker.

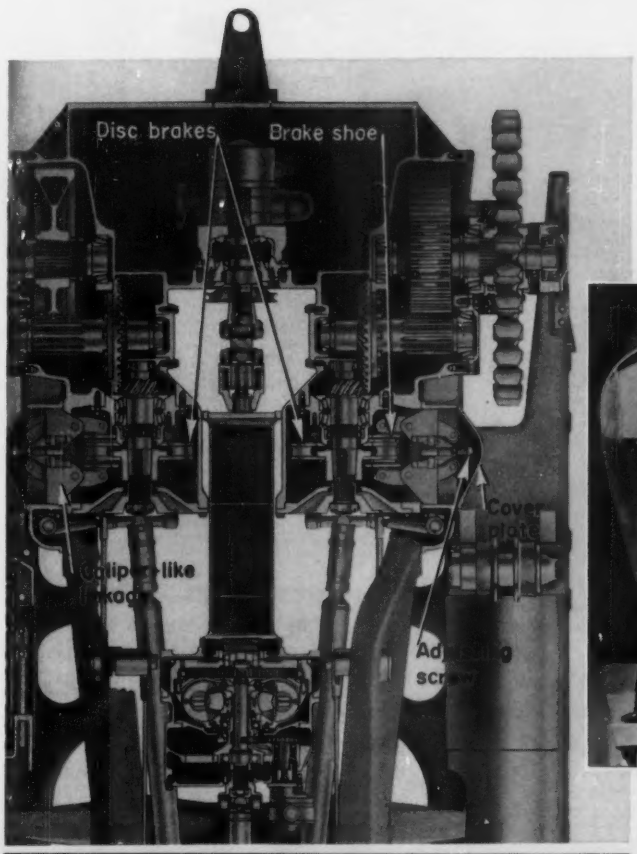
Radio with prefabricated unit system, called Servo-Chassis comes from Telefunken GmbH, Hannover, Germany.



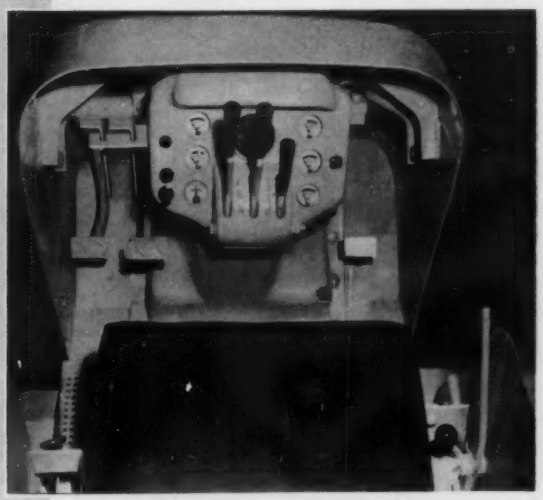




Caliper Motion Clamps Brake Discs in New Crawler



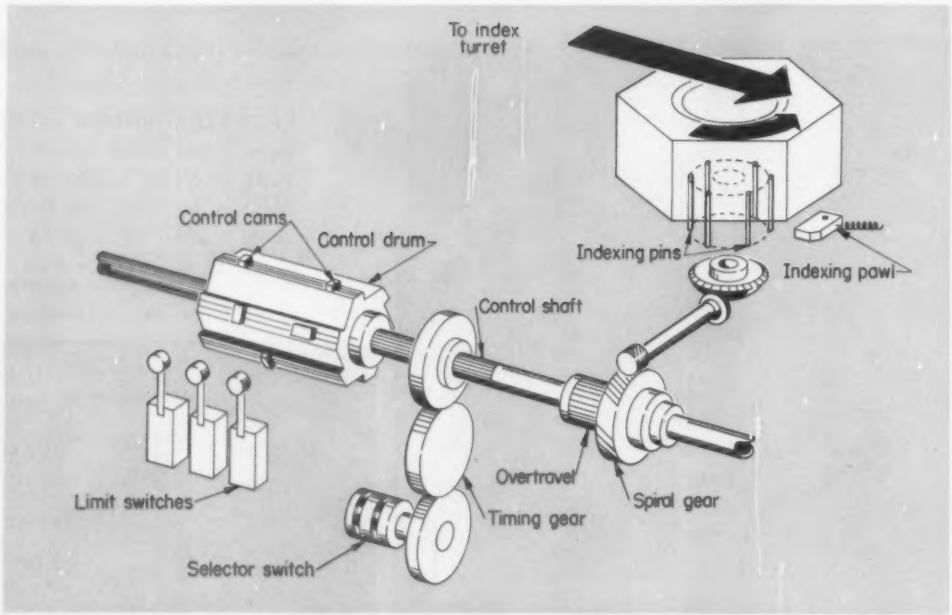
CALIPER-LIKE MOTION activates braking surfaces of disc brakes mounted on the twin drive shafts of a new crawler. Adjusting screw compensates for wear and uneven braking. It's easily reached by removing a cover plate just ahead of the tractor's drive wheel.

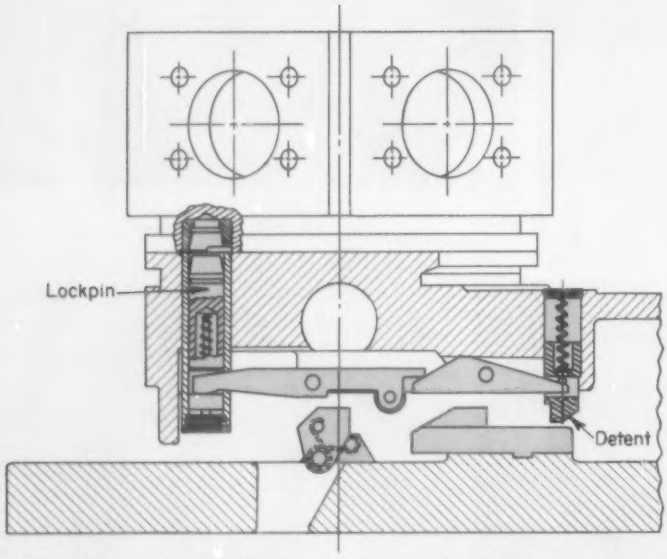


CONTROL PEDESTAL SUPPORTS brake pedals as well as other major driving controls. Unit design reduces production costs and simplifies operation of the machine. Levers to the right of the seat operate associated equipment like shovels, bulldozer blades, etc.

UP-FRONT POSITION puts driver in command of his vehicle. Hot air from the 100-hp motor behind him is blown to the rear by dual fans running from the rear power takeoff. Eimco Corp., Salt Lake City, Utah, makes the crawler.

Indexing Turret Turns

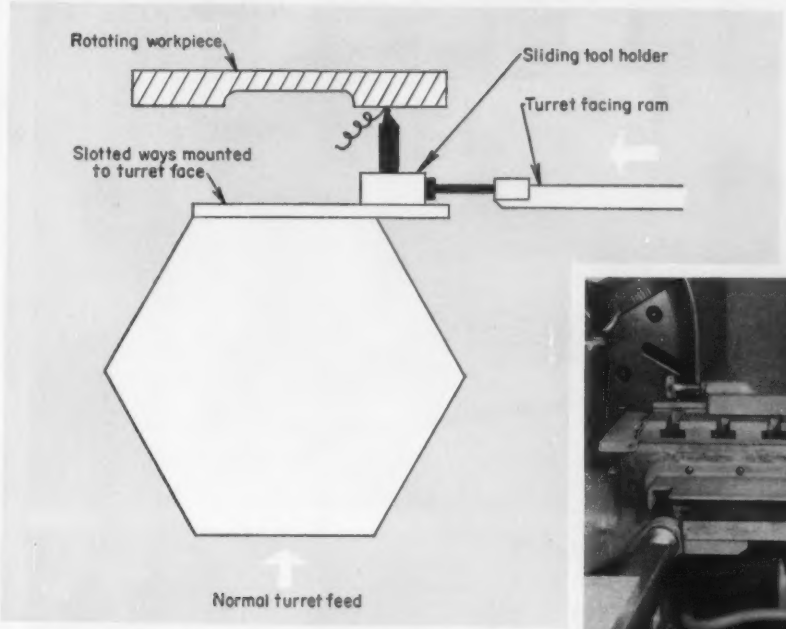


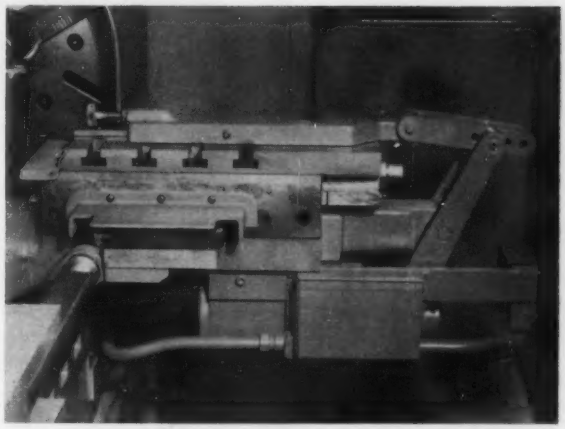


TURRET IS COUPLED directly to a splined control shaft through a spiral gear in a new automatic turret lathe. Indexing the turret automatically calls for the proper sequence of operations to correspond to the turret position. A drum on the control shaft carries cams corresponding to feed start and stop positions. Turning the shaft brings the proper set of cams in line with corresponding limit switches. Timing gear connects the shaft to a multiple knife-blade switch that chooses proper sequence from six (corresponding to six turret positions). A cam-operated master switch cuts out current during switching to protect delicate knife-blade contacts from sparking.

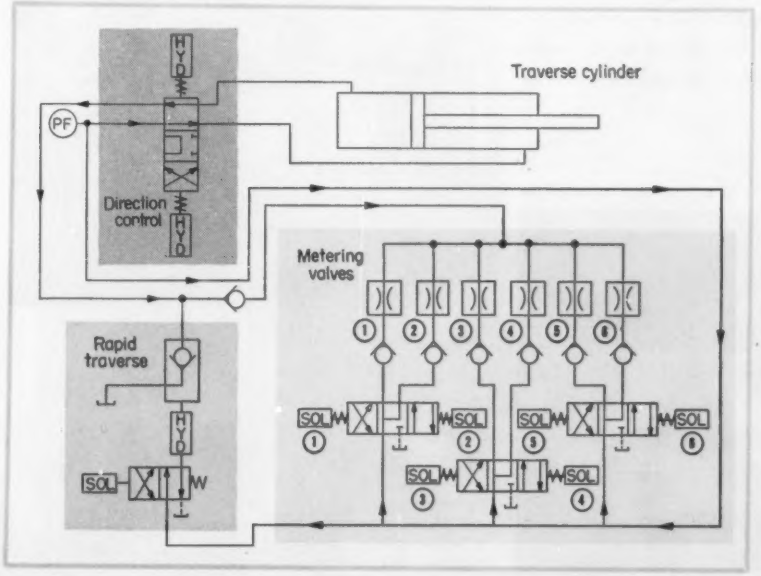
RETURN TRAVERSE MOTION is used by pawl-and-pin mechanism to index the turret. Safety feature is detent that stops forward movement until lock pin is in place to hold turret in positive angular position. Pin and detent are positively linked to move together.

Control Shaft to Select Program



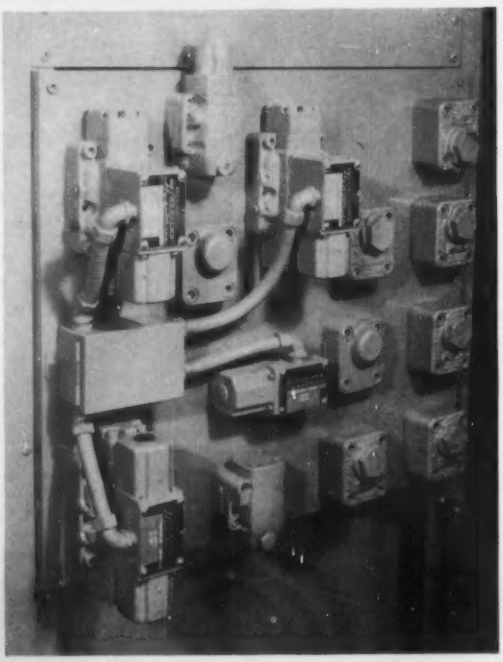


ADDITIONAL FACING FUNCTION is provided by an auxiliary crosshead-mounted ram. Its cylinder operates from the same servohydraulic system that controls automatic features of the turret so there's a minimum of control duplication. The tool is mounted by a short, slotted ways to the turret head, so controls for automatic turret position the tool and an additional switch on the turret control panel brings the facing ram into operation.

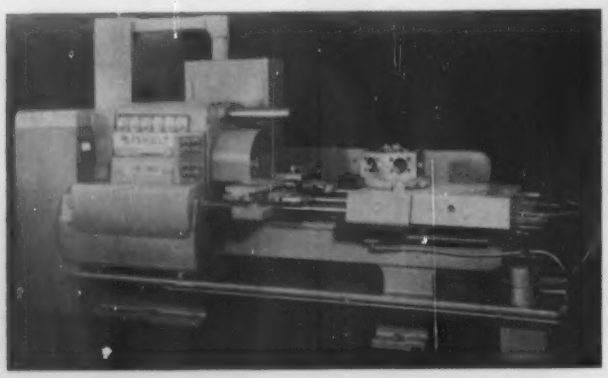


EXTRA-FAST RAPID TRAVERSE system dumps fluid from traverse cylinder directly into the reservoir. Controlled feeding speed is produced by passing exiting fluid through a metering valve. Valves for each of six operations can be set to predetermined speeds. Valve leaks that destroy accuracy of feed are avoided by a back-pressure system that holds check valves closed. To avoid surges, pressure is maintained on metering system during rapid traverse by another check valve.

BUILT-IN PROGRAM CENTER sets up complete program of six operations for the automatic lathe. Each abscissa represents one of six operations corresponding to six turret positions. Each ordinate represents a specific machine function which may be selected or altered for each operation. Six flow metering valves controlling rate of feed are adjusted by dials at the top of the cabinet. Rate of feed is indicated by meter at the left. Start and stop positions are controlled by adjusting cams on cam drum. Any operation can be changed as needed for one cycle and then quickly restored to previous setting. Operations can be repeated or bypassed on tough pieces.

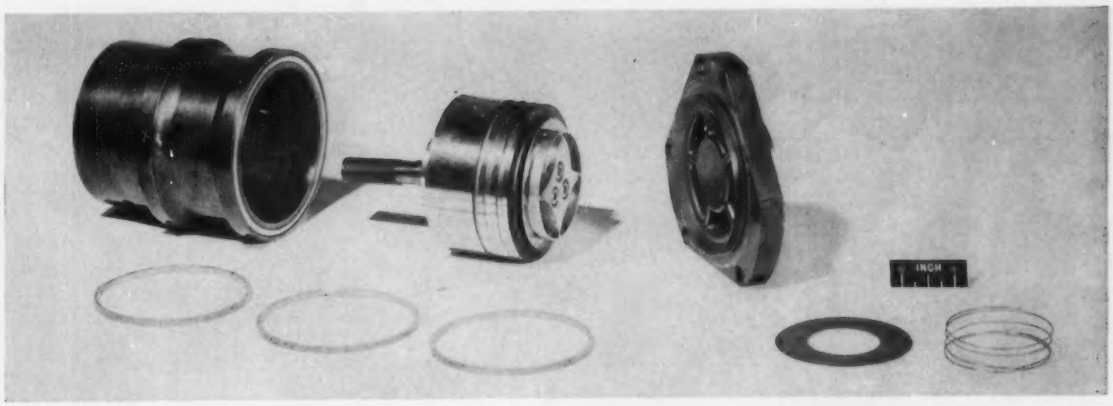


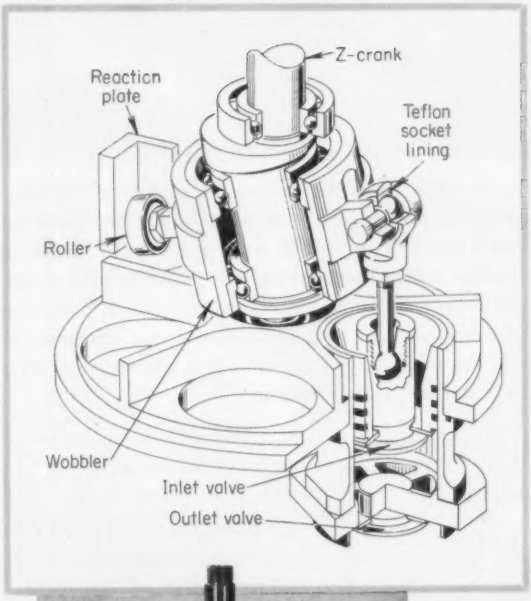
EASY ACCESS FOR SERVICE is arranged by mounting valves on a panel in the back of the headstock cabinet. Standard components are bolted on for quick replacement with a minimum of downtime.



Automatic turret lathe with unified controls and closely controlled hydraulic feed rate is a development of Gisholt Machine Co., Madison, Wis.

"Bucket" Design Reduces Cavitation In Wobble Pump for Cryogenic Fluids

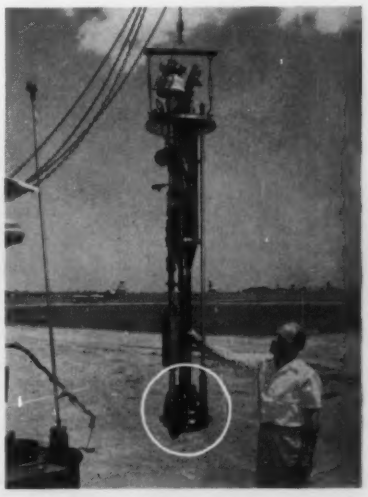




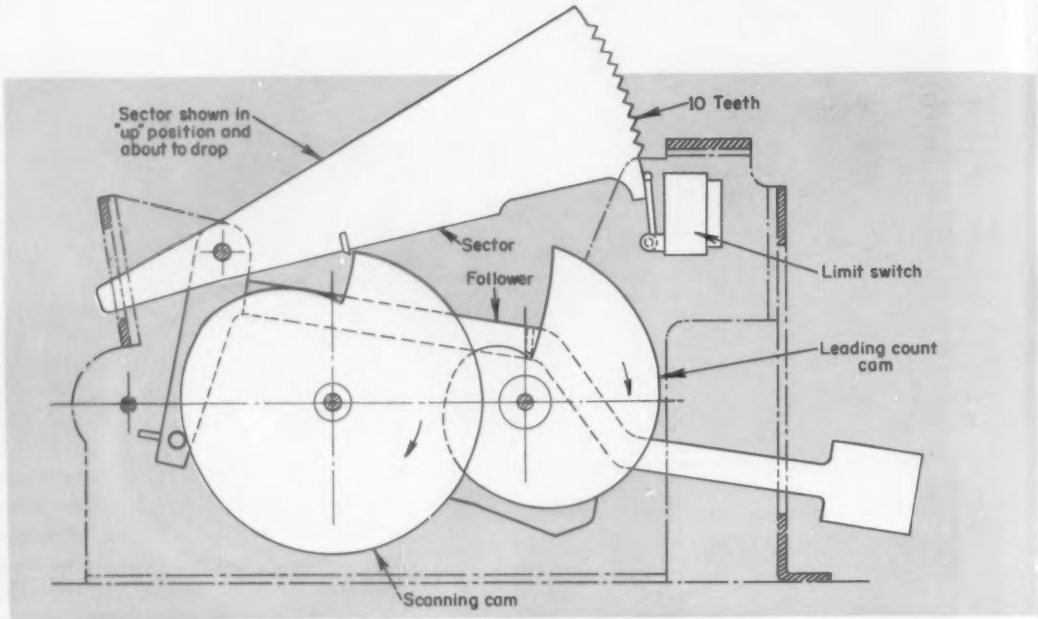
FLUID FLOWS in one direction only through a new cryogenic pump incorporating inlet valves in the pistons. Eliminating flow reversal of conventional piston pumps cuts down on work loss which tends to evaporate the fluid. Cavitation is also reduced by eliminating need for a pressure drop on the intake stroke to accelerate the fluid column in the piston. The only significant pressure drop remaining results from change of flow area across the valve. Identical inlet and outlet valves have cross sections equal to 35 per cent of cylinder cross section.

Z-CRANK OPERATES the wobble plate. Its torque is resisted by a roller that bears on a simple reaction plate. Piston rings and ball-socket linings are Teflon for long wear and good lubrication in low-temperature, low-viscosity liquid hydrogen. The pump has been operated in JP-5 and liquid nitrogen as well.

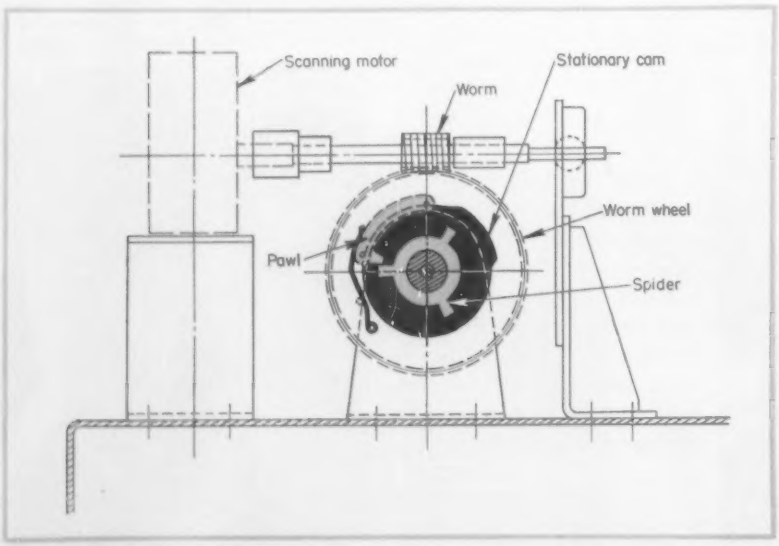
Cryogenic pump for liquid hydrogen was developed at NASA's Lewis Research Center, Cleveland, Ohio, and was reported by Arnold E. Biermann and William G. Shinko.



Limit Switches Count Gear Teeth

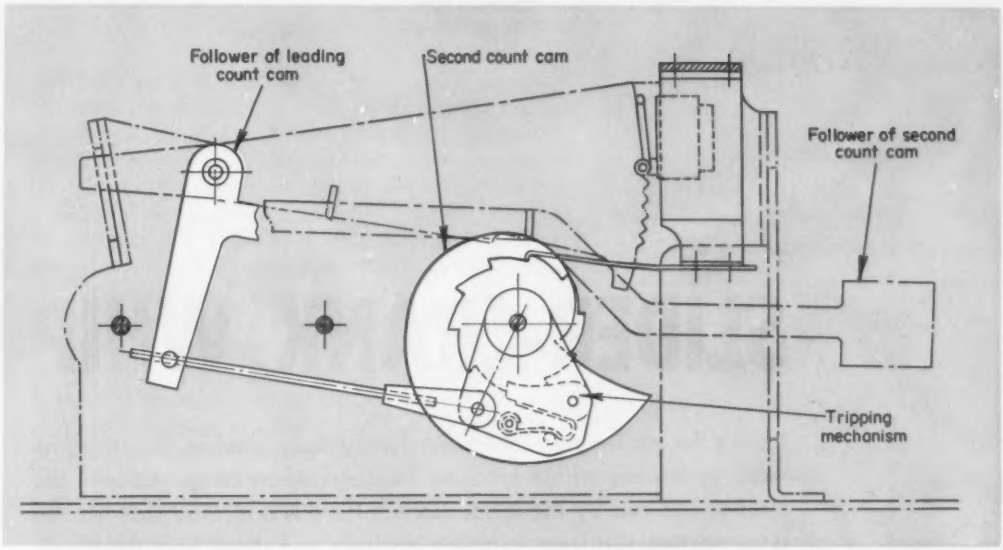


CAM ACTION OF GEAR TEETH operates a limit switch to send a pulsed signal indicating water height in a rain gage. Up to ten teeth pass the limit switch on a single readout, furnishing ten possible signals that differ in the number of pulses transmitted. Four of these units are coupled to transmit a four-digit number. Leading count cam rotates as a float (not shown) rises. The follower's height is determined by the cam surface. The follower limits the downward motion of the gear sector, establishing the number of teeth that pass the limit switch. In a typical readout operation, incoming demand signal triggers rotation of the scanning cam which turns to let the gear sector drop and "feel" the follower's position. As the scanning cam continues to turn, the gear sector rises to its rest position, operating the microswitch as it moves.

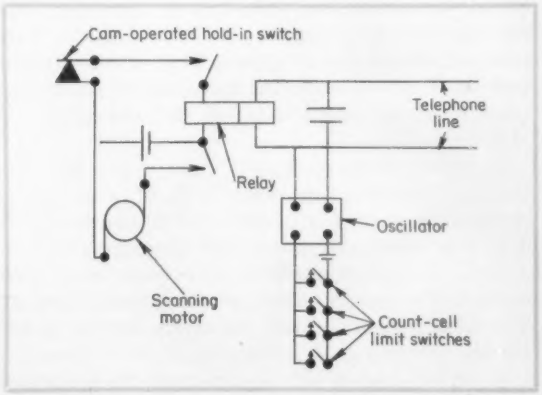


STATIONARY CAM PULLS pawl out of engagement with spider arm to provide a 10-sec delay in scanning response while it moves to the next arm. Pawl transmits drive from the worm wheel to the spider which is geared to the scanning cam shaft. The delay insures that receiving equipment will pick up the start of the signal.

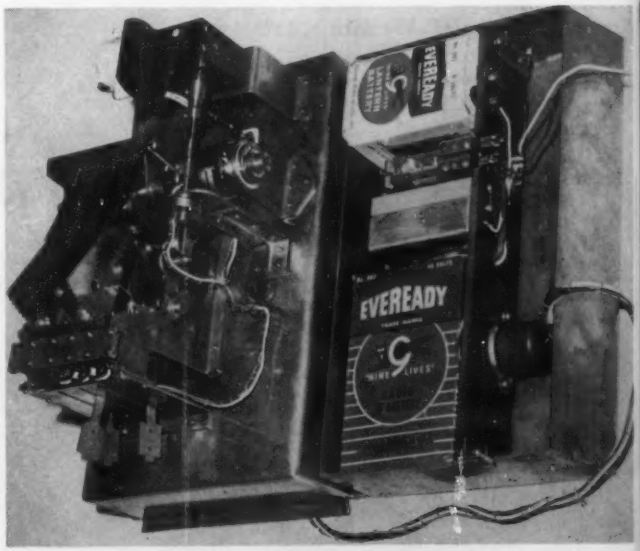
For Digital Readout in Telemeter



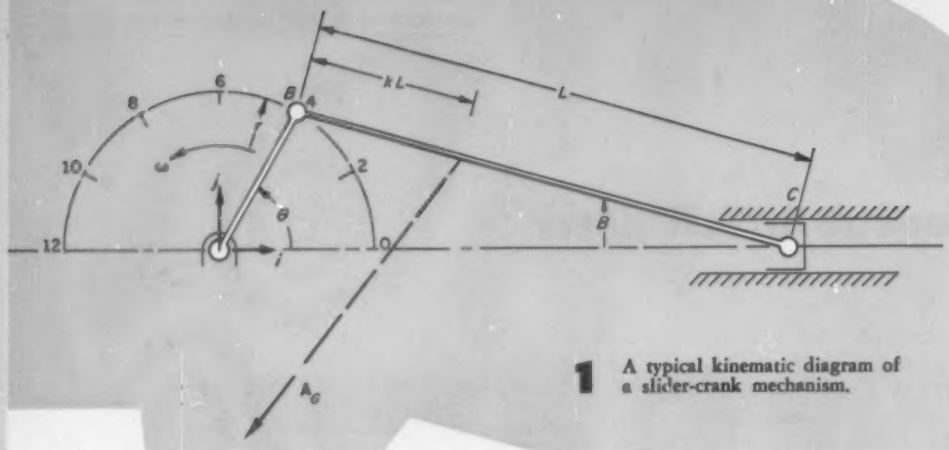
COUNT IS PASSED from one count cell to the next by a ratchet-and-pawl device linked to the follower of the preceding count cell. As the follower drops on the tenth count, the succeeding count cam is advanced one-tenth of a complete rotation.



INCOMING PULSE STARTS the scanning motor and closes a cam-operated hold-in switch. When readout is complete, hold-in switch is tripped to open the circuits. A dashpot is included in the hold-in switch system to establish a reset time.



Mechanically scanned four-digit telemeter was developed By E. Betz of the University of New South Wales, Australia, and is now being used by the Hunter Valley Research Foundation for pluviometer telemetering.



1 A typical kinematic diagram of a slider-crank mechanism.

SLIDER-CRANK WHIP

Inertia forces in high-speed machinery may double or triple the working stresses within machine members when compared with the stresses induced by the loads alone. Here is a method that isolates a connecting rod from its adjoining links and shows how the amplifying effects of inertia forces can be predicted by calculation.

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Assistant Professor
Department of Engineering Mechanics
North Carolina State College
Raleigh, N. C.

Nomenclature

$\mathbf{A}_G$ = Vector acceleration of center of gravity
$_tA_G$ = Magnitude of acceleration A_G perpendicular to rod, called the tangential component, in. per sec^2
e = Variable distance along rod between center of gravity G and line of action of force W, in.
I = Mass moment of inertia of rod, lb-in.^{2}
k = Fractional proportion of L between crankpin and center of gravity
L = Length between pin centers of connecting rod, in.
M = Mass of connecting rod, lb-sec^2 per in.
r = Crank radius, in.
W = Force defined as whip
x, y = Crank pin coordinates, in.
z = A function of y, in.
α = Angular acceleration of rod, rad per sec^2
ω = Constant angular speed of crank, rad per sec
ω_L = Variable angular speed of connecting rod, rad per sec

NUMEROUS methods are available for solving problems in the dynamics of slider-crank mechanisms. Graphical methods are conventional. Simple analytical methods are approximate. Some approximate methods furnish correction factors that are adequate for almost any design purpose. In general, the differences between calculations performed by approximate and exact methods depend upon the length ratio of the connecting rod and the crank.

In other words, a 4 to 1 ratio shows less discrepancy between an exact and an approximate method than a 2½ to 1 ratio. An old rule designates 4 to 1 as a boundary ratio. For ratios greater than 4 to 1, an approximate analysis is regarded as good enough. For smaller ratios, an exact analysis, or an approximate method with correction factors, is advisable.

Much routine calculation of today is performed on machines. Frequently, an exact solution of a problem upon a desk calculator is just as easy and convenient to achieve as an approximate or graphical solution. Associated with a calculator, of course, is a plan or program for carrying out the calculations.

This article programs the calculations for finding

the effects of "whip" on the connecting rod of an ordinary slider-crank mechanism. A simple example illustrates a tabular application of the program.

Whip Concepts: Clearly to isolate the connecting rod from the other links of the mechanism, consider Fig. 1 and 2 and the Nomenclature. Crank r is assumed as rotating counterclockwise at constant angular speed ω. To specify a certain angular speed for a slider-crank mechanism of known proportions, as for example $\omega = 3000$ rpm, also completely defines the velocities and accelerations of any and all points and links of the mechanism.

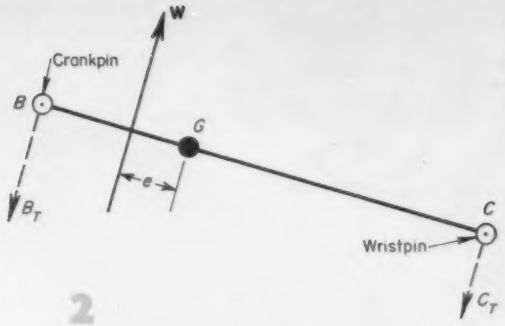
At each position in a cycle of motion, center of gravity G of the connecting rod has an acceleration, as vector A_G, Fig. 1. This acceleration, reversed in direction and multiplied by the rod mass, is the inertia force acting on the rod. The accelerations change from one position to the next; hence, one of the problems of the present analysis is to find the position at which the accelerations cause maximum whip.

At the dead points in a cycle of motion, the tangential components of these inertia forces are zero, but at all other positions an inertia force has a finite tangential component. The tangential component is of major concern here because this analysis assumes that only the dynamic forces (or couples) perpendicular to the rod cause whip. Accordingly, the stress effects of whip for design purposes are shear and bending within the rod.

Likewise, angular acceleration of the rod contributes toward whip as well as components of normal accelerations. The magnitude of angular acceleration and inertia couple is the product of the (mass) moment of inertia of the rod and its angular acceleration. Fig. 2 illustrates a single force, W, acting perpendicular to the rod and at distance, e, from the center of gravity. This one force is the resultant or so-called "whip." To find that position in a cycle of motion at which the magnitude of whip is greatest and its corresponding line of action relative to the center of gravity of the rod are the specific objectives of this presentation.

Summary of Relationships: Equations for use in calculating whip are stated in Table 1. They are not derived here because most of them are readily verified by trigonometry and Fig. 1. One way to verify the ${}_tA_G$ relationship is to sum the components of acceleration perpendicular to the rod.

Constants in the equations are enclosed by brackets. They need be calculated only once for a given problem. In Table 2 the equations are arranged in column form for convenience in performing calculations.



2

On an isolated connecting rod, "whip" is a single force, W, perpendicular to the rod and acting at a distance e from the center of gravity.

Table 1—Equations for Calculating Whip

$$x = r \cos \theta \tag{1}$$

$$y = r \sin \theta = L \sin \beta \tag{2}$$

$$z = \sqrt{L^2 - y^2} = L \cos \beta \tag{3}$$

$$\omega_L = \frac{\omega x}{z} \tag{4}$$

$$\alpha = [\omega^2 (L^2 - r^2)] \frac{y}{z^3} \text{ ccw} \tag{5}$$

$${}_tA_G = \left[\frac{\omega^2}{L} \right] y(x + z) - kL\alpha \tag{6}$$

$$W = - M_t A_G \tag{7}$$

$$e = \frac{I\alpha}{W} \tag{8}$$

Graphical Calculation of Terms: If a new figure is drawn as in Fig. 3, with the addition of two new triangles, every term in ${}_tA_G$ may be recognized as a length on the figure.

The graphical procedure is: For any crankpin position B, scale the x and y co-ordinates. Now rotate crank r to the 90-deg location shown and draw the rod length from its end to the centerline position to locate fixed point D. This will scale the constant dimension $(L^2 - r^2)^{1/2}$. Next rotate x to the 90-deg location shown and scale dimension z from the dashed triangle. For an analysis at any position of the rod, the only things that have to

Table 2—Tabular Program for Finding Maximum Whip

Operation Number	Symbols, Units, Operation	Position 0	2	4	6	8	10	12
1	θ, deg	0	30	60	90	120	150	180
2	$x = r \cos \theta$, in.	3.000	2.598	1.500	0.0	−1.500	−2.598	−3.000
3	$y = r \sin \theta$, in.	0.0	1.500	2.598	3.000	2.598	1.500	0.0
4	$y^2 = (3)^2$	0.0	2.250	6.750	9.000	6.750	2.250	0.0
5	$z^2 = L^2 - (4)$	100.0	97.75	93.25	91.00	93.25	97.75	100.0
6	$z = (5)^{1/2}$, in.	10.0	9.882	9.657	9.540	9.657	9.882	10.0
7	z^3	1000.0	966.0	900.5	868.1	900.5	966.0	1000.0
8	$y/z^3 = (3)/(7)$	0.0	0.001553	0.002885	0.003456	0.002885	0.001553	0.0
9	$a = -8{,}982{,}000$ (8)	0.0	−13,950	−25,900	−31,040	−25,900	−13,950	0.0
10	$x + z = (2) + (6)$	13.0	12.48	11.16	9.540	8.157	7.284	7.0
11	$y(x + z) = (3)\ (10)$	0.0	18.72	29.10	28.62	21.19	10.93	0.0
12	$\omega^2(11)/L = 9870\ (11)$	0.0	184,800	287,000	282,500	209,100	107,900	0.0
13	$k L a = 5\ (9)$	0.0	−69,750	−129,500	−155,200	−129,500	−69,750	0.0
14	$_tA_a = (12) + (13)$	0.0	115,100	157,500	127,300	79,600	40,150	0.0
15	$W = -0.006873\ (14)$	0.0	−791.1	−1080	874.9	547.1	276.0	0.0
16	$I a = 0.05818\ (9)$	0.0	−811.6	−1507	−1806	−1507	−811.6	0.0
17	$e = (16)/(15)$	...	1.026	1.393	2.064	2.755	2.941	...

be scaled are x, y, and z. The constant dimension $(L^2 - r^2)^{1/2}$ needs only one scaling.

Example: The numerical example aims to illustrate simply and directly a method of calculating whip. For this purpose, it is kept free of practical design details. The connecting rod, for instance, is taken merely as a rectangular steel strip, 3/4 × 5/4 × 10 in. The crank, of 3-in. radius, rotates counterclockwise at 3000 rpm, or 100π rad per sec. Thus the mass is

$$M = \frac{9.375(0.283)}{g(\,=386)}$$

$$= 0.006873 \text{ lb-sec}^2 \text{ per in.}$$

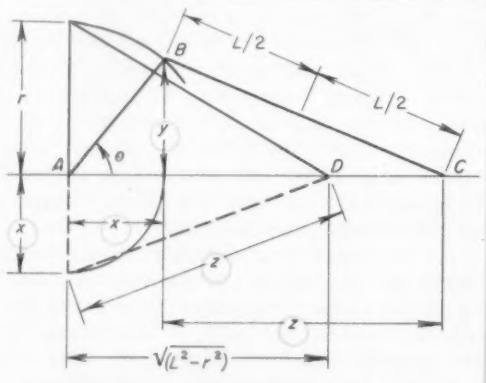
and the moment of inertia is

$$I = 0.006873\left(\frac{10^2 + (1.25)^2}{12}\right)$$

$$= 0.05818 \text{ in.-lb-sec}^2$$

The center of gravity is midway between the crankpin and the wristpin so that k is $\frac{1}{2}$.

Moreover, the 30-deg intervals of Table 2 are assigned the even-numbered positions. This practice preserves the odd numbers for identifying an in-between position in case additional calculation seems advisable toward finding the exact position of a maximum. Item 15 of Table 2 is the magnitude of whip. It happens to be greatest at position 4 in the present example.



3 Graphical determination of variables in Equation 6.

For $W = 1080$, $L = 10$, and $e = 1.393$, the corresponding reactions, B_T and C_T, Fig. 2, are 690 and 390 lb, respectively. These forces on the rod translated into bending and shearing stresses yield s_t = 13,280 psi and s_s = 1103 psi. Such stresses are the consequences of whip alone. They are superimposed upon the stresses caused by any external loading of the member and the longitudinal inertia effects.

Extensible Hoover vacuum-cleaner hose of vinyl, top, is shrunk around a spiral wire skeleton, itself coated with vinyl. Lightweight vinyl garden hose, bottom right, is reinforced with high-strength fiber braid. Beverage tubing, bottom center, is nontoxic and transparent for ease of inspection. Rigid PVC pipe, bottom left, is corrosion resistant and has good dimensional stability.

Part 2

Vinyl Properties

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TENSILE strengths of vinyl-chloride materials can be made to vary as much as 4 to 1, based on intended end-use. At the high end are rigid PVC compounds with strengths up to 8000 psi; elastomeric extrusion and molding compounds are at the opposite end, testing in the 2000 psi range. This article, second in a series, presents data on properties and characteristics of vinyls, and the effects of environmental conditions on design considerations.

Properties

Vinyl-chloride polymer and copolymer plastics are classed either as rigid or nonrigid materials. Nonrigid, elastomeric materials all contain a plasticizer.

Table 1—Elastomeric Extrusion and Molding Compounds

Property	ASTM Method	Compound* A	B	C	D	E	F
Hardness, Durometer (Shore A)	D-676	70	80	90	78	75	88
Tensile strength (psi)	D-412	1600	2450	2800	2300	1675	1500
Modulus† at 100 per cent elongation (psi)	D-412	630	1150	1800	1100	800	1450
Elongation at break (per cent)	D-412	430	370	325	365	375	125
Cold-flex temperature (C)	D-1043	−46	−18	−30	−40‡	−20	....
Specific gravity	D-792	1.33	1.39	1.30	1.29	1.41	1.39
Typical cost, truckload ($ per lb)	.....	0.28	0.255	0.33	0.395	0.45	1.05

Applications: A. Gaskets, bumpers; B. Handle grips, toys; C. Tubing, hose, welting; D. Low-temperature cable jacket; E. Refrigerator gaskets; F. Conductive products such as automotive ignition wire.

*Designations of compounds are arbitrary.
†Tensile stress.
‡Brittle temperature, −45 C (ASTM D-746).

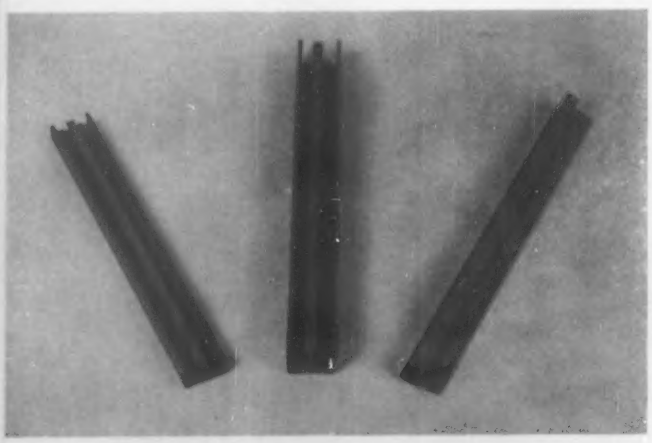
Nonrigid Compounds: Extrusion and molding compounds of elastomeric vinyls, Table 1, generally are characterized by a low filler content. This is evidenced by the relatively low specific gravity, particularly of compounds A, C, and D. This characteristic accounts partly for the low cold-flex temperature property, necessary for products requiring continuous flexing in practically all weather conditions.

Compound E, used for refrigerator gaskets which are often assembled in contact with styrene door liners, contains a nonmigrating plasticizer. Ordinary plasticizers weaken styrene, since they migrate from the surface of the vinyl into the styrene. This compound also has the quality of being free of odor.

Compound F will carry enough current to light a lamp and can be used for RF shielding gaskets and as shielding in microphone cables when assisted by an imbedded "drain" wire.

Factors that afford high temperature resistance and oil resistance characteristics to vinyl compounds are generally: 1. Type of plasticizer. 2. Low filler content. 3. High-quality lead stabilizer. These characteristics are particularly important in vinyls used as insulating materials, Table 2.

Compounds K and L, Table 3, partly bridge the gap between the rigid and nonrigid groups, but are basically in the elastomeric or nonrigid class. These vinyls are used mainly for wire insulation.



Extruded PVC slides for equipment doors and panels are corrosion-resistant and easy to maintain.

Rigid Compounds: Characterized generally by good dimensional stability and chemical resistance, rigid (unplasticized) PVC materials, Table 4, are used mainly for pipe and ducting for handling corrosive liquids and vapors. Compound M is easily printed and vacuum-formed and is used for three-dimensional maps, advertising displays and packaging. Another use is in light diffusers for indirect lighting fixtures.

Compound O finds application in high-impact pipe in oil fields and chemical and food-processing plants. This material, in sheet or tube form, is readily cold stamped and formed. Compound N sacrifices some impact strength for greater chemical resistance.

Environment

The environment in which a plastic part must work is a major consideration in its design. The useful life of a vinyl product, like that of other plastics, can depend upon exposure to heat, cold, weather, or chemicals and solvents. Power or signal losses vary in vinyl insulated wires and cables with current alternating frequency.

Temperature: Vinyls are affected by temperature changes in several ways, due to their thermoplastic nature as well as the plasticizer content of elastomeric types. Physical properties decline as temperatures increase. Distortion under load occurs at about 140 F with many rigid PVC products. Elastomerics stretch easily at elevated temperatures; burst strength in hose products is therefore reduced.

High temperatures volatilize certain plasticizers and cause embrittlement. The highest Underwriters' Lab approved rating for vinyl chloride is 105 C.

Low temperatures have a significant effect on flexural stiffness of vinyl compounds, Fig. 1. As the plastic stiffens with cold, it embrittles, becoming less resistant to impact and bending. Type and amount of plasticizer affect this property as does concentration of filler.

Temperature also has an effect on the electrical properties of vinyls, Fig. 2. Direct-current volume

resistivity, normally measured at 50 C, drops appreciably with small temperature increases.

Thermal expansion of PVC is greater than that of metals with which it may come into contact. The coefficient for PVC ranges in the area of 3×10^{-5} in. per in. per deg F, generally 2 to 5 times the coefficients of the common metals. Thermal conductivity is low for most vinyls, about 1 Btu per hr-sq ft-in.-deg F. Adding filler to the compound increases this rate markedly.

Compressive Loads: Another limiting design factor with many vinyls, especially elastomeric types, is

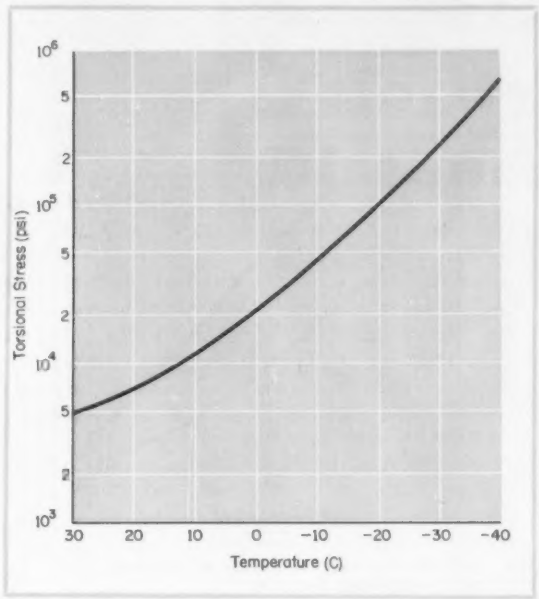


Fig. 1—Flexural stiffness versus temperature of a typical elastomeric vinyl material, compound G.

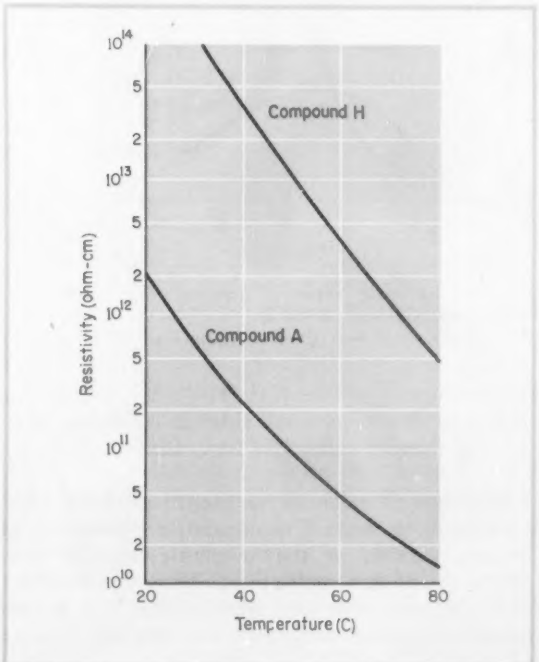


Fig. 2—Resistivity versus temperature curves for elastomeric vinyl compounds A and H.

Table 2—Electrical-Grade Insulating Compounds

Property	ASTM Method	Compound* G	H	J
Hardness, Durometer (Shore A)	D-676	80	88	93
Tensile strength (psi)	D-412	2200	2800	2800
Modulus† at 100 per cent elongation (psi)	D-412	1350	1600	2100
Elongation at break (per cent)	D-412	350	310	320
Cold-flex temperature (C)	D-1043	−20	−20	−8
Brittle temperature (C)	D-746	−22	−24	−14
Specific gravity	D-792	1.37	1.37	1.38
Heat aging—elongation retention	UL Std			
7 days, 100 C (per cent)		80	102	....
7 days, 136 C (per cent)		...	...	86
Volume resistivity at 50 C (10^{12} ohm-cm)	D-257	15	30	7
Dielectric strength, 1/32-in. wall on 14 AWG wire (v per mil)	UL Std	800	800	800
Dielectric constant at 1 kc	D-150	5.8	5.2	5.3
Dissipation factor at 1 kc	D-150	0.13	0.10	0.12
Typical cost, truckload ($ per lb)	.....	0.2525	0.255	0.34
Rating, UL		Class 11 60 C heat resistant	T, TW, 60 C oil resistant, 80 C heat resistant	90 and 105 C heat resistant

Applications: G. Portable cords, plugs, fixture wire; H. Building light and power wire, blanket-heating wire; J. Machine tool, appliance, radio and TV wire, transformer wire, resistance-heating wire.

*Designations of compounds are arbitrary.
†Tensile stress.

Table 3—Semirigid Compounds

Property	ASTM Method	Compound* K	L
Hardness, Durometer (Shore D)	D-676	48	56
Tensile strength (psi)	D-412	3390	3930
Modulus† at 100 per cent elongation (psi)	D-412	3080	....
Elongation at break (per cent)	D-412	255	195
Specific gravity	D-792	1.34	1.37
Heat aging—elongation retention	UL Std		
7 days, 121 C (per cent)		....	95
Volume resistivity at 50 C (10^{12} ohm-cm)	D-257	100	70
Dielectric constant at 1 kc	D-150	3.7	4.1
Dissipation factor at 1 kc	D-150	0.07	0.06
Typical cost, truckload ($ per lb)	.....	0.35	0.44
Rating	.....	60 C wire	80§ and 105 C wire

*Designations of compounds are arbitrary.
†Tensile strength.
§For thin-walled insulation on business-machine wire.

Table 4—Typical Rigid Compounds

Property	Compound* M Polyvinyl Chloride-Polyvinyl Acetate Copolymer	N Type I (Normal Impact)	O Type II (High Impact)
Hardness, Durometer (Shore D)	80	85	80
Tensile strength (psi)	7,500	8,000	7,000
Flexural strength (psi)	15,000	13,000	11,000
Compressive strength (psi)	11,000	10,000	9,000
Izod impact strength (ft lb per in. of notch)	0.5	0.6	16.0
Deflection temperature at 264 psi (F)	145	165	155
Flammability	Self-extinguishing		
Chemical resistance	Good	Excellent	Very good

*Designations of compounds are arbitrary.

Flexible telephone handset cord, top, is colorful, easy to clean, and retains its coiled shape. Color-coding is used in distribution cables, both sheathed, center, and unsheathed, bottom. Both require maximum weather and sunlight resistance.

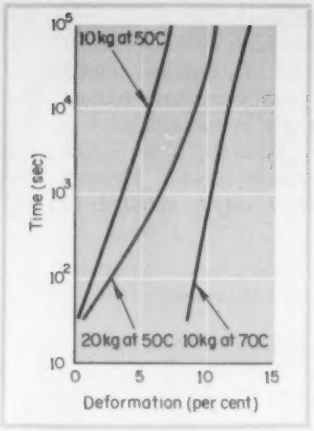


Fig. 3 — Compressive deformation of a 0.5 in. cube of elastomeric compound H.

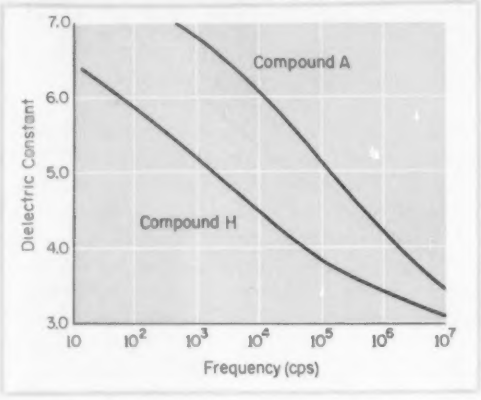


Fig. 4—Dielectric constant versus ac frequency for elastomeric compounds A and H.

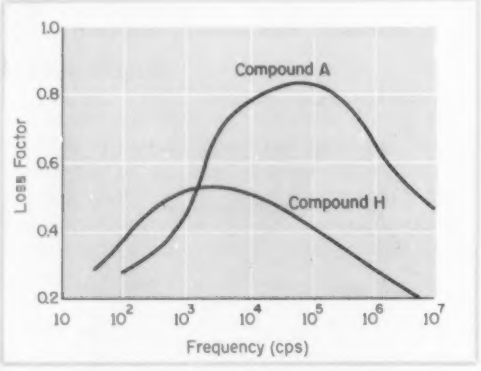


Fig. 5—Loss factor versus ac frequency for plasticized vinyl compounds A and H.

compressive deformation, Fig. 3. Tensile, compressive, bending, and twisting forces tend to distort thermoplastic parts. Elastic memory tends to bring the pieces back to their original shape if forces are not applied for long periods or at high temperatures. Since organic plastics are not purely elastic in behavior, as are most metals, they do not recover their original form completely. Formulations vary in this regard, with plasticizer and filler content as the significant modifiers. Unless reinforced, thermoplastics are seldom recommended as permanent load-bearing members.

Current Frequency: The dielectric constant and loss factor of vinyl insulating materials are affected by ac frequency as shown in Fig. 4 and 5. Formulation can change the peaking frequency. Compound H, Fig. 5, contains some clay filler, compound A does not, although both contain calcium carbonate filler. The type and amount of plasticizer affects the height of the peak.

Ultraviolet Light: Gradual degradation in most vinyl chlorides is caused by ultraviolet light through oxidation and similar reactions. However, stabilizer and pigment systems are available that have maximum screening power and ability to inhibit yellowing. Telephone companies use vinyl-coated wiring for long-distance rural communications, planning for up to 20 years' service.

Chemicals: Vinyl chloride resin itself is extremely chemical resistant. Plasticizers vary in this respect, but generally, vinyl chloride compounds have very good resistance to water, salt-water spray, ozone, oxygen, detergents, oils, greases, alcohols and many other solvents, acids, and caustic solutions. Vinyls are not generally recommended for frequent or prolonged contact with gasoline or aromatic solvents.

Flame: Generally, the chlorine content of vinyl resins makes most vinyl compounds self-extinguishing. Antimony oxides, or selected plasticizers such as phosphate esters, are often used to give the compounds an added measure of flame-proofing.

Fungus: When required, fungus resistance can be built into vinyl compounds through plasticizer selection and through addition of fungicides.

Migration: Tendencies of plasticizers from vinyl compounds to migrate to adjacent surfaces such as lacquer, varnish, or styrene plastic must be considered for certain applications. When direct contact under pressure with such sensitive materials is contemplated, special compounds are required.

Next Article discusses the various forms of vinyl and their applications.

Chart gives quick estimate of relationships among

Acceleration
Velocity
Distance
Time

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ESTIMATES of velocity, displacement, and time at constant acceleration of powered vehicles or free-falling bodies are frequently required. The accompanying chart gives a "quick-look" answer by providing approximate solutions for the equations,

$$t = \sqrt{\frac{2d}{a}}$$

and

$$v = \sqrt{2ad}$$

where t = time, sec; d = distance, ft; a = acceleration, ft per sec^2; v = velocity, fps. For convenience, on the chart, acceleration is shown in terms of gravity units, g = 32.2 ft per sec^2; time in milliseconds = (0.001 sec) and distance in both feet and inches.

Example 1: A vehicle is accelerated at 10g through a distance of 1000 ft. What is the velocity at the end of travel, and the time required to travel the 1000 ft?

SOLUTION: Locate the intersection of acceleration = 10g with distance = 1000 ft. The lines of constant velocity and time through this point are the solution: v = 800 fps and t = 2500 msec or 2.5 sec.

Example 2: An object dropped from a height of 150 in. is stopped in a soft medium over a distance of 2 in. What is the velocity at impact and the average deceleration?

SOLUTION: Locate the intersection of the 150-in. distance line and the 1g acceleration line. On the velocity scale, v = 28 fps. Draw the 28-fps velocity line. At the intersection of this line and 2-in. distance line read a = 75g.

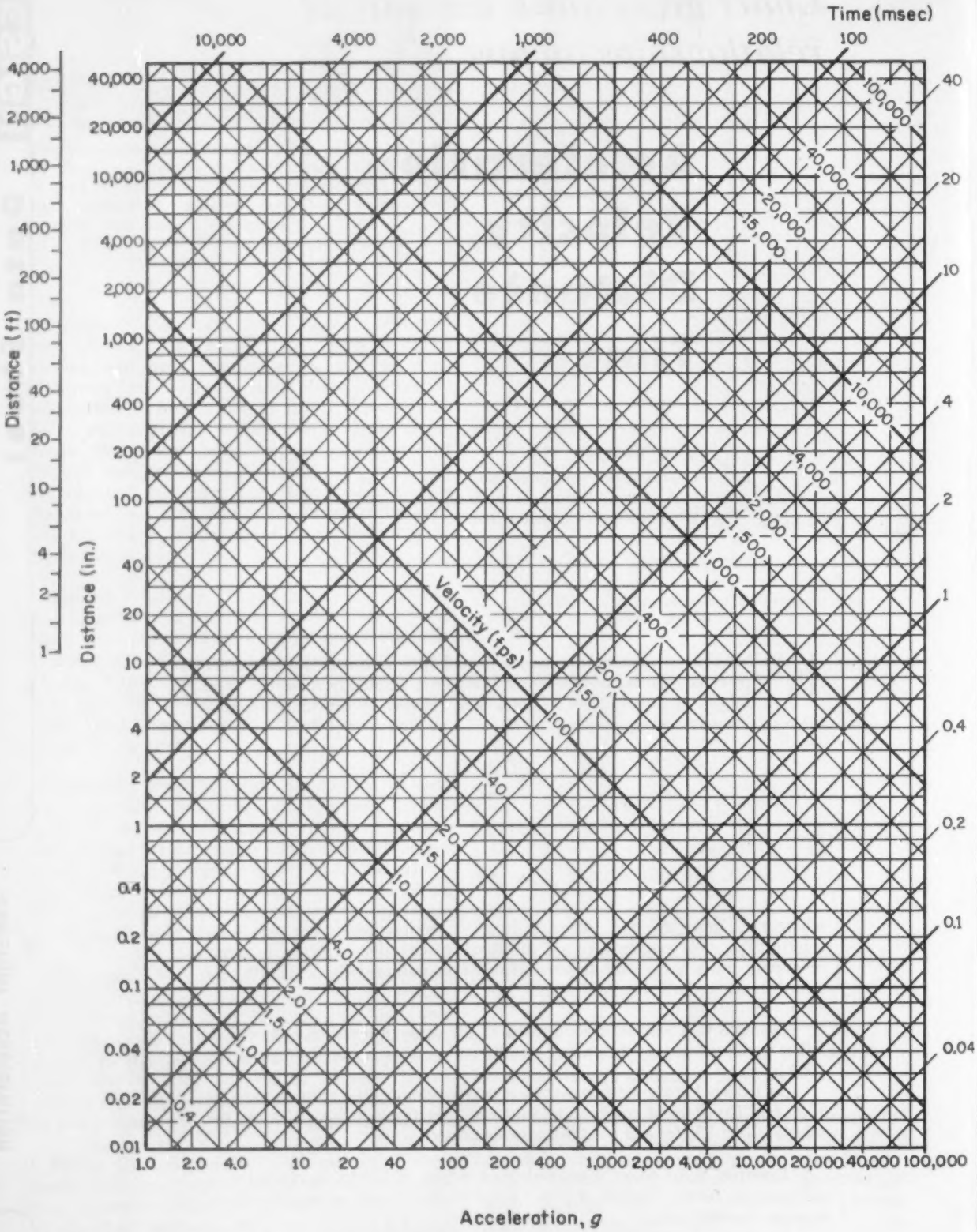

Fig. 1—Chart for determining velocity, distance, and time relationships at constant acceleration.

Basic concepts of

Modular Design for Mechanized Assembly

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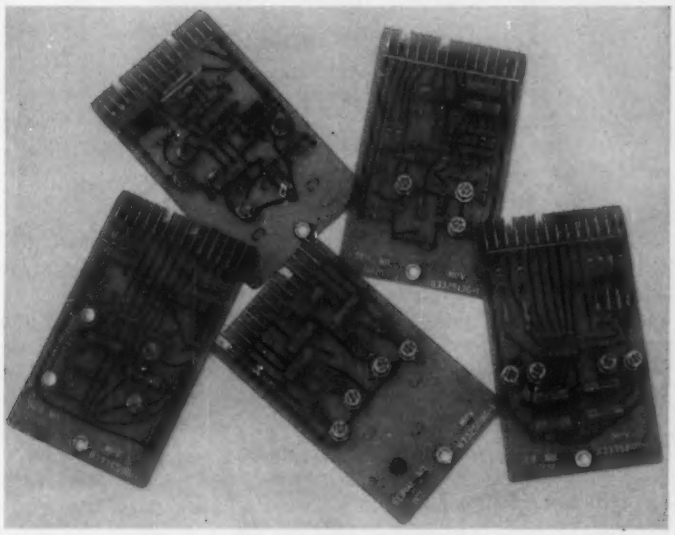


Fig. 1—Typical electronic modules.

MODULES are thought of as building blocks which permit interchangeability, replaceability, and general usage in more than one end product. Two considerations are predominant: Components of modules should be designed for automatic production, and modules themselves should be designed for mechanized assembly.

Design of Modular Components

Development of modules depends on extensive use of standardization techniques. Standardization can simplify manufacturing operations, and may permit the use of identical tooling and assembling equipment. In modular design, the application of standardization is basically associated with the components within the module and to the base which receives them. In electronic modules, the base is often a printed foil-clad board and the components are resistors, capacitors, diodes, and transistors, Fig. 1.

The components vary in size and number according to module functions. It is frequently appropriate to perform several electronic functions with one module. When the module performs a mechanical function, basic design considerations are the same as for electronic equipment.

A grid to locate components eliminates the use of conventional dimensions and tolerances, Fig. 2. The grid influences the design of components to be mounted on the base. If two or more holes are needed to retain a component, the grid controls both location and orientation. The grid makes it necessary to use a standardized design procedure in locating components. Rather than stifle the ingenuity of the engineer, this kind of standardization simplifies the design process.

Components which are to become a part of the modular assembly need special consideration. Where mechanized assembly is an objective, components must be stored in magazines, hoppers, reels or other suitable means. These components must have configurations that permit complete control from storage to final assembly. When components, such as resistors and capacitors, have axial leads, their configuration makes them quite suitable for mechanized assembly. They can be magazined, or taped, and can be re-

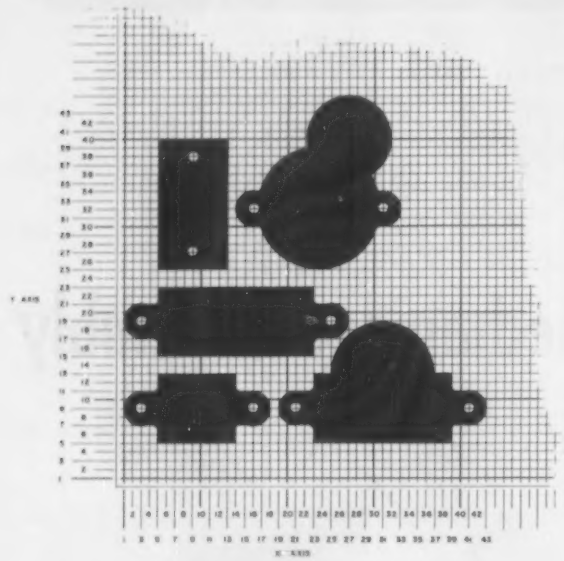


Fig. 2 (Above)—Graphic specification of component locations on circuit board grid.

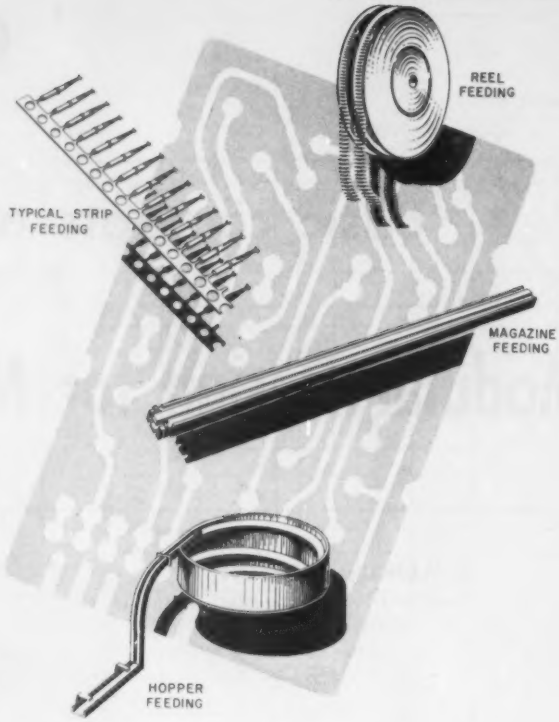


Fig. 3 (Right)—Methods of component feeding.

liably controlled in machine operation.

Standardized grids and proper component designs compel the design engineer to build experimental and preproduction units in conformity with actual production techniques. As a result, design must be based on a thorough understanding of the production and assembly operations involved.

Principles of Mechanized Assembly

A typical mechanized assembling system can be considered the equivalent of five basic units: 1. Component feeding unit. 2. Positioning unit. 3. Assembling unit. 4. Power unit. 5. Control unit.

Component feeding unit has two functions: It stores components, and it brings them to the assembling position. Some typical methods of component feeding are illustrated in Fig. 3. Although many component hoppers are commercially available, they often must be designed to meet special requirements of unique components. Among the simplest types of components to store and handle are those which are punched and formed but remain on the strip of material from which they were made.

In the assembly of electronic modules, components must be selected from a number of storage units and then fed into the machine by a common carrier. An air track has functioned successfully for this purpose. Air jets bring the components to the assembly position very rapidly. Belts and chains are also used to transport components to the assembling position.

Proper orientation of the component at the assembly position can be one of the most difficult problems in component handling, particularly if the component is small and fragile. The solution must make use of simple and reliable mechanisms.

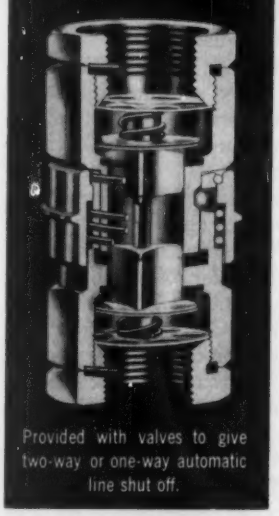
Positioning Unit performs two functions: It locates the component with reference to the assembling or operation tool, and it picks up a new assembly base from the storage hopper, simultaneously ejecting the previous base.

Planning the positions of module components on printed board of base plates begins after the smallest and largest base elements have been determined. All possible positions of components should be determined. Many manufacturers are presently producing components so that the leads and fastening means are spaced to utilize a standard 0.10-in. grid, or multiples thereof, Fig. 2.

Assembling Unit does not need to be exclusively an assembling machine. Its function may be punching, forming, cutting, embossing, or any other conventional operation. Some machines mechanically feed strip material from reels. As a general rule, preferred practice is to avoid a combination of operations.

Power Unit usually consists of air-reduction valves and filters. Air as an actuating means has proven highly successful for this type of equipment. An air-pressure supply of 90 to 110 psi is recommended because it is generally available.

Control Unit can be set-up to use a program reader and a keyboard to manually select components and component positions. It can also have switches for power, heat, automatic, manual, start and stop. Such a unit can be built into the assembling equip-



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Circle 479 on Page 19

A small company used its first thermostat as a part of the "damper flapper"—a control unit which operated the damper on a coal fired furnace. Thus, automatic heating was born in 1885.

The company became known as Minneapolis-Honeywell and for 75 years has been recognized as a leader in the development of thermostats and heating controls. The famous clock thermostat ("A" above) appeared in 1906. It featured a big, brassy, eight-day clock. A far cry from this original masterpiece is Minneapolis-Honeywell's modern, precision built and attractive electric clock thermostat ("B" above). This newest clock thermostat automatically adjusts room temperature to the living schedule—constant warm temperature by day, cooler room temperature by night.

The actuating elements in Minneapolis-Honeywell's new thermostats—both the electric clock model and the revolutionary round thermostat ("C" above)—are made of Chace Thermostatic Bimetal. Chace has been supplying Minneapolis-Honeywell with precision thermostatic bimetal since 1925 . . . a long and productive relationship, indeed.

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ment, or it can be a separate unit, and it can control more than one equipment. An advantage of electronic control is the ability to program for a large variety of work.

There are several ways of storing information: Punched cards, punched endless tape, and magnetic tape. In a punched card, for example, various combinations of punched holes create signals for grid positions and components. The last signal from the card recycles the whole operation. Activities within the machine cycle can be protected by interlock switches to prevent repeating and jamming. Mechanized assembly equipment is not necessarily limited to long runs. Punch-card control for short runs becomes feasible when there is an appreciable cost savings at changeover.

ASME Paper No. 60-MD-11, "The Concept of Modular Design for Mechanized Assembly," presented at the Design Engineering Conference and Show, New York, May, 1960, 7 pp.

Co-ordinate Filing System

A. F. GLIMN, and R. D. GREENWAY, General Electric Co.

BASIC principles of co-ordinate indexing are combined with the advantages of generic classification. Indexing techniques and computer programs are designed to retrieve only the information actually required by the user.

Fundamentally, a classification system is based on the philosophy that all information can be partitioned into mutually exclusive classes and sub-classes. But this practice has definite disadvantages: First, the hierarchy of classes which seems desirable for certain users might be unsatisfactory for others. Second, regardless of the hierarchy used, all classification schemes consist of a limited number of classes or access points. This is to say that the index has a restricted vocabulary.

It is not possible to solve the restricted vocabulary problem by extending the number of classes and sub-classes ad infinitum. As the number of classes is increased, the problem of matching a document to a particular class becomes more

Circle 480 on Page 19

complex. This is due to the fact that true mutual exclusiveness never exists in practice.

Requirements of storage and retrieval systems that could not be satisfied with classification techniques have led to investigation of other approaches. As a result, there has been an increasing trend toward the development of co-ordinate indexing techniques.

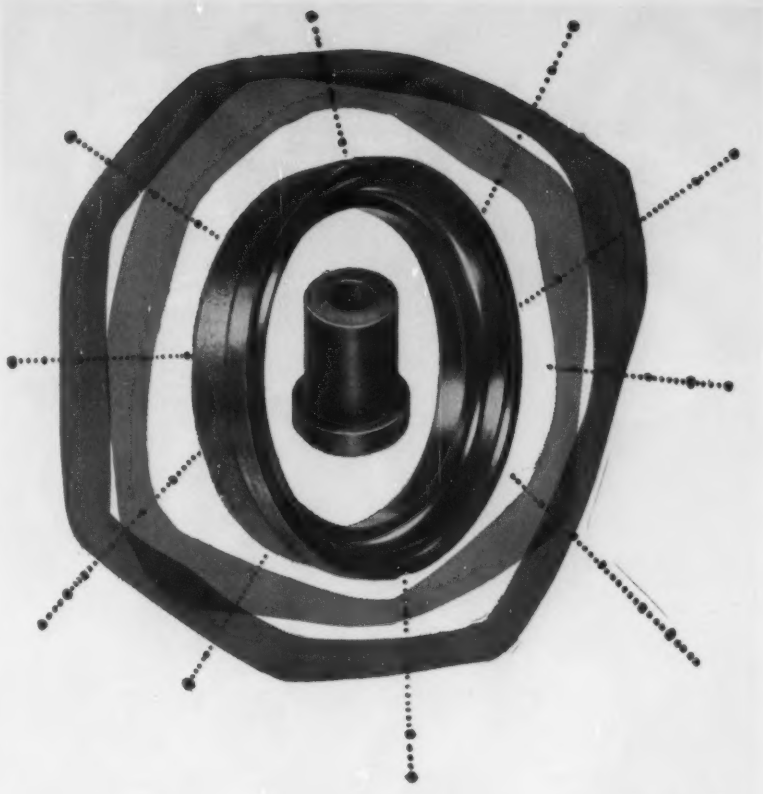
Co-ordinate indexing is based on the fact that subject matter in documents can be represented by descriptive terms, often called keywords, which identify the document. New keywords are added when necessary. Documents are filed chronologically according to accession number.

During the early stages of operation any co-ordinate index system will contain more keywords than documents. After a time, a cross-over point is reached, and eventually, keywords rarely need be added. There are no categories in a co-ordinate index so the indexer is relieved of making the decision concerning which category is the "best."

Simple co-ordinate indexing systems are not suitable for searching on a fine level of detail. This is due to the fact that no distinction is made between words in and out of context.

In an "enriched" co-ordinate system, the indexer prepares a record of words and groups of words taken from the text. Any implied information which is deemed necessary to the index may be added parenthetically. A "header," which includes information about the entire document such as title, author, source, and date, is added. Any generic information applying to the entire document is also added as part of the header. The generic information enables searches in broad subject categories. The header and all indexed words (the body) for a particular document form a unit record. The body of the unit record is subdivided into broad topics. Thus, a search can be made for information denoted by the intersection of terms *within* a topic.

Each word in the unit record is assigned a class indicator called the "prefix." Approximately 100 prefixes are sufficient to prevent am-



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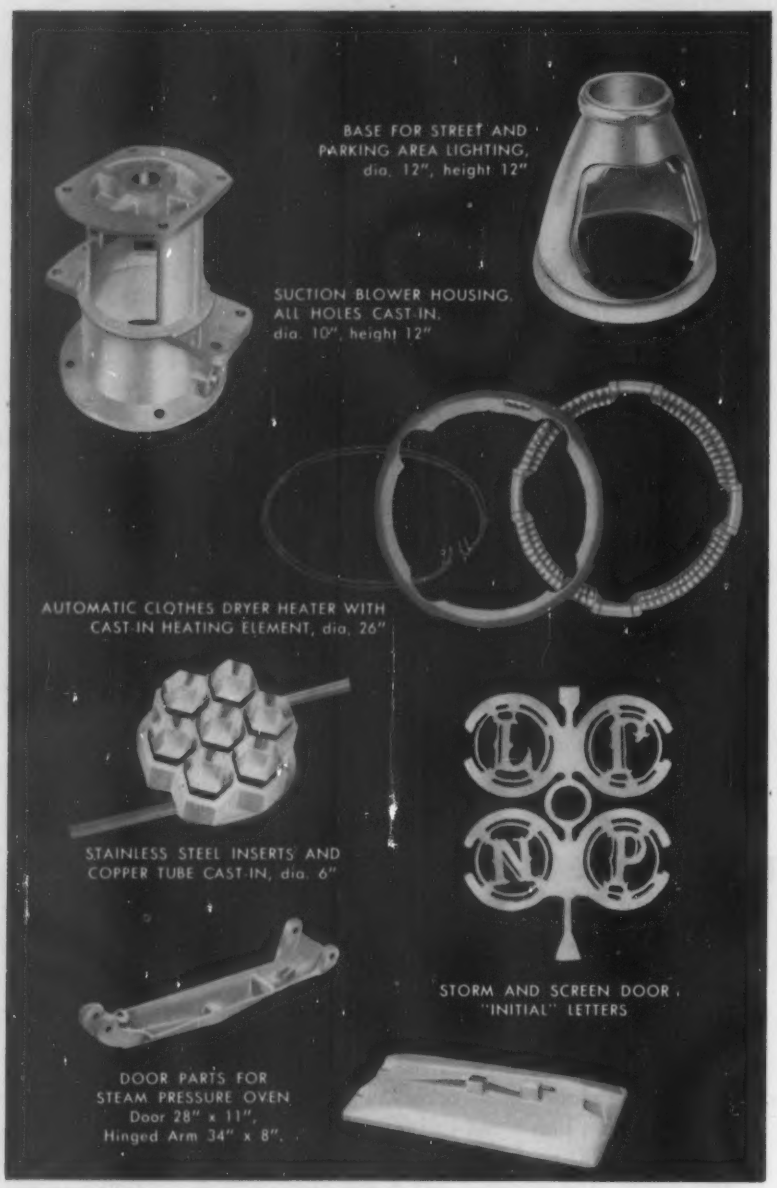
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biguity and loss of information due to a word being removed from context.

Some of the indexed words are provided with "descriptor links" and "role indicators" as well as prefixes. These links and role indicators preserve syntactical relationships which a human being will infer from context but which a machine will not recognize. Role indicators are used to distinguish between the subject and object of a phrase or denote a word which is used as a modifier.

A computer which manipulates the system performs three basic functions: Storage, retrieval, and system growth. The basic unit of information in the system is a term which may be any combination of alphabetic or numeric characters. The system has the capability to associate up to three attachments with each word, so that a term may consist of keyword, prefix, role, and link.

Specification of retrieval criteria may be at many levels. One or more terms must be specified, but the complete specification of all characters of a term is not necessary because a universal match—or "don't care"—character is available.

AIEE Paper No. CP 60-807, *"Information Storage and Retrieval—Part 1. Dogs, Cats, and Indexing," presented at the AIEE Summer General Meeting, Atlantic City, N. J., June* 1960, 10 *pp.*

processes

Theory and Application of the Plasma Arc

R. M. Gage, assistant manager of development, Electric Welding, Development Laboratory, Linde Co.

Plasma arc torches produce an arc plasma flame which has two advantages over conventional chemical flames of torches operating on oxygen and a fuel gas: 1. The temperature of arc plasma flames can be many times greater. 2. The gas of arc plasma flames is of a selective and controlled composition.

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On some meter-in circuits, with the "bypass" port piped to tank, the "inlet" and "outlet" can be piped as above, but any excess oil fed to the valve will flow to tank. As long as the fluid motor or cylinder is working at less pressure than system relief valve setting, the Rivett 3-port flow control will maintain oil flow to the work as set, the bypass port will flow excess oil to tank at the work pressure, and therefore the pump is using horsepower only at the rate determined by work requirements.

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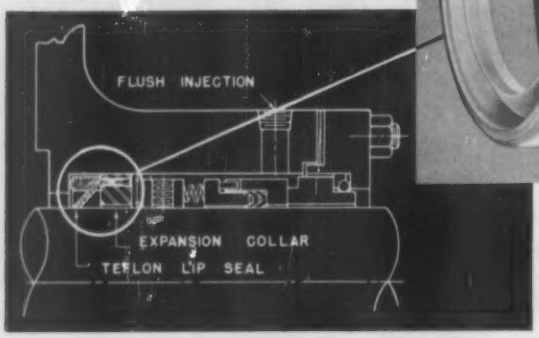
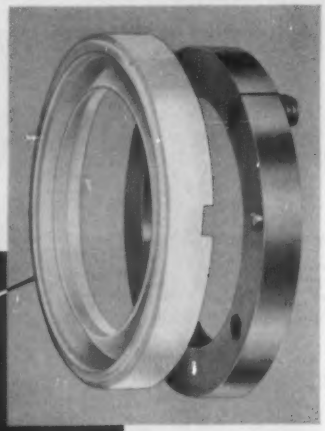
Circle 483 on Page 19

DURA LIP SEAL

For use with Dura Seal to control liquid injection in stuffing boxes

FOR HANDLING ABRASIVE FLUIDS AND SLURRIES





DURA LIP SEAL

Composed of two parts: Left, Teflon lip sealing ring; Right, split expansion Collar for retaining lip sealing ring in operating position.

DURA LIP SEAL provides a flow control for liquid injection in stuffing boxes. Its purpose is to prevent abrasives in the process fluid from interfering with the function of the Dura Seal. A split Collar is expanded firmly against the stuffing box bore retaining a Teflon lip sealing ring that regulates the amount of dilution. FOR MORE INFORMATION, WRITE FOR BULLETIN NO. 491-MD

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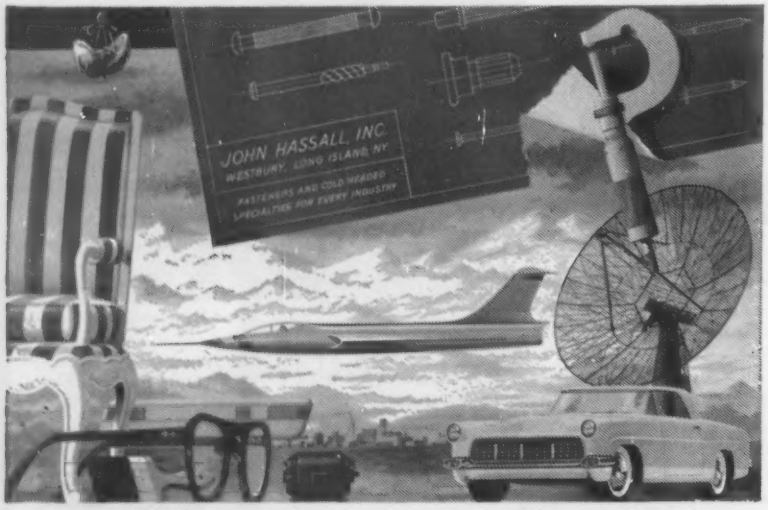

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Plasma arc plating process makes possible fast and accurate mass production of parts from ultra-high melting point materials. The hot gas stream in the torch can melt and accelerate, to high velocity, particles of any known solid inorganic material which will melt without decomposition. When these molten particles strike the work piece, they impact to form a dense high-purity coating.

Structures are made by depositing the coating material onto a brass mandrel machined to the desired shape and then removing the mandrel. Many complex geometric shapes can be made from hard-to-fabricate refractory metals. Surface coatings can be deposited on almost any base material including graphite, brass, molybdenum, aluminum, and plastics.

SAE Paper No. T41, "Theory and Application of the Plasma Arc," presented at the SAE National Aeronautic Meeting, New York, April, 1960, 4 pp.

hydraulic

Creep Failure Time For Pressure Vessels

F. P. J. Rimrott, assistant Professor, Dept. of Mechanical Engineering, University of Toronto, Earl J. Mills, Principal Mechanical Engineer, Battelle Memorial Institute, and Joseph Marin, Professor and Head, Dept. of Engineering Mechanics, Pennsylvania State University

Creep-failure time for thin, thick, and very thick-walled cylindrical vessels of circular cross section with closed ends subjected to constant internal pressure.

When a pressure vessel is subjected to internal pressure, and is made from a material which exhibits creep, the vessel will expand. If the internal pressure is held constant during expansion, the load on the wall will increase. At the same time, the thickness of the wall decreases. The result of these two simultaneous effects is that the expansion of the vessel is continuously accelerated until the wall thickness

has decreased and the load increased to such an extent that the strength of the material is no longer sufficient and fracture of the vessel occurs.

Theoretical time-to-fracture in the case of simple tensile creep is in good agreement with experimental results. The basis of approach is to use true stress and true strain. The creep-failure time is then defined as the time at which the true strain reaches infinity. The present paper extends the foregoing concept to the problem of combined stresses.

ASME Paper No. 60-APM-7, "Prediction of Creep Failure Time for Pressure Vessels," presented at the Summer Conference of the ASME Applied Mechanics Div., University Park, Pa., June, 1960, 6 pp.

materials

Structural Alloys under Rapid Heating and Loading

J. R. Kattus, head, Metallurgy Div., Southern Research Institute, and D. W. McDowell Jr., metallurgist, Development and Research Div., International Nickel Co.

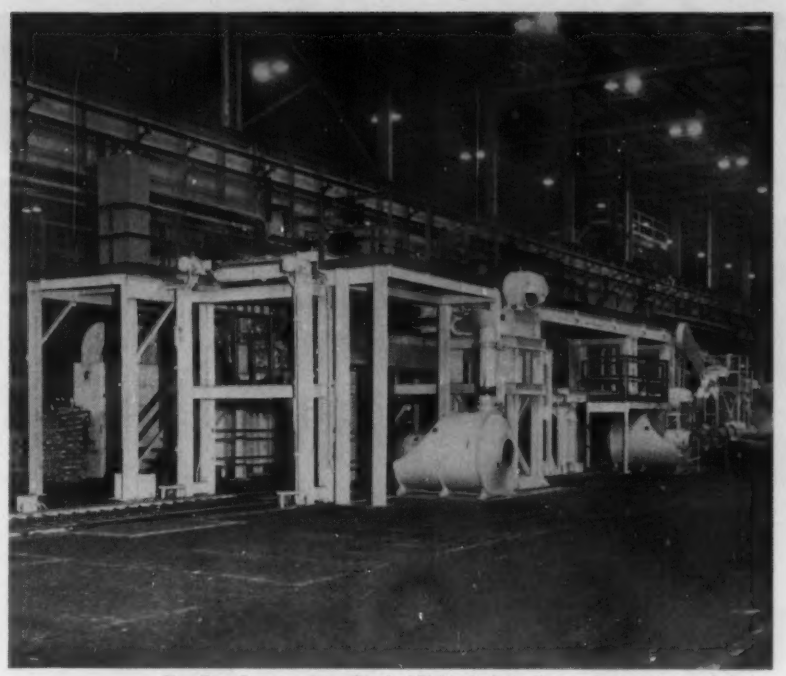
Rapid tensile and short-time creep properties for three commercial stainless steel sheet materials, three commercial nickel-base sheet alloys, and one experimental stainless steel which had been cold rolled at −105 F. Specimens were heated to test temperatures up to 2000 F within 30 sec.

The load-carrying capacity of all the alloys increases with decreasing exposure times from 30 min to 1 sec at temperature under load.

High-strength stainless steels are stronger than the nickel alloys at the lower temperatures, but the nickel alloys retain useful load-carrying capacity to higher temperatures than the stainless steels do. Short-time creep strengths of the nickel alloys in the range 1400 to 1800 F are roughly equivalent to those of the stainless steels in the range 1000 to 1400 F.

Type 304 stainless steel had been cold rolled at −105 F to achieve a yield strength exceeding 350,000 psi at room temperature. At temperatures up to 1200 F, it had higher tensile strength than any commercial grade of stainless steel.

ASTM Paper No. 71, "Strength of Structural Alloys under Rapid Heating and



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Loading," presented at the Sixty-third Annual meeting of the Society, June-July, 1960, 12 pp.

Fusion-Bond Coatings For Plastic-Cladding Metals

W. R. Pascoe, technical service manager, Whirlclad Div., The Polymer Corp.

Description and advantages of a new fluidized plastic coating process. A preheated object is dipped into a bed of finely divided, dry, fluidized powders which melt and fuse on heated surfaces to form a continuous film.

It is possible to apply a controlled uniform thickness of coating, without the use of solvents, from 5 to 50 mils, in a single dip. It is not necessary to apply multiple coats to obtain suitable film thickness. Since dry plastic powder becomes molten only briefly, uniformity of coating is a characteristic of the process even over sharp edges. Solvent resistant plastics can be applied: Nylon, polyethylene, chlorinated polyethers, and fluorocarbons. Smooth finishes can be obtained on relatively rough surfaces without extensive substrate preparation. The coatings can be machined to close tolerances. The process is adaptable for automatic processing of parts in large volume.

Techniques are available for applying fusion bond finishes to a wide variety of substrates with the same equipment system.

SAE Paper No. 180D, "Fusion Bond Coatings—A New Technique for Plastic Cladding Metal," presented at the SAE Summer Meeting, Chicago, Ill., June, 1960, 7 pp.

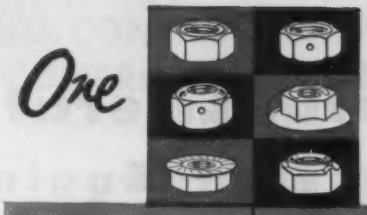
TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.; papers 50 cents to members, one dollar to nonmembers.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 40 cents to members, 80 cents to nonmembers.

ASTM—American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

SAE—Society of Automotive Engineers, 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.



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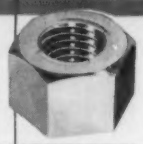
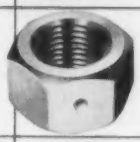
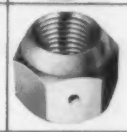


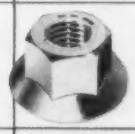
MF **UNI-TORQUE** — A free starter with lock at the top. Withstands severe vibrations. Cuts assembly time.



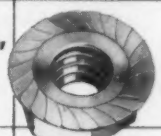
MF **TWO-WAY** — The Lock's in the center of nut. Can be applied from either end. Permits bolt end to be flush with, or below, top of nut.



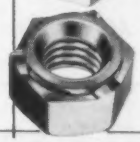
MF OPEN END **CAP NUT** — Has two-way center-of-nut lock. Used on furniture, appliances, toys, lawn mowers, tools, etc.



MF UNI-TORQUE **FLANGE NUT** — Combination lock nut and washer. Use on oversized holes; where extra bearing surface is needed.



MF **"WHIZ-LOCK"** FLANGE NUT — This one spins on. Serrations take a firm grip on work. Break loose torque higher than seated torque.



MF PILOT TYPE **WELD NUT** — You can have it with or without lock. Simplifies assemblies by means of self-locating pilot.

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For copies of any literature listed, circle Item Number on Yellow Card—page 19

Adhesives, Coatings, Sealers

Catalog contains information on oil-soluble and oil-resistant elastomers, structural adhesives, coatings, and sealers. General characteristics and methods of application are included, as well as typical applications. Section on design concepts is provided for each product. 12 pages. Minnesota Mining & Mfg. Co., Adhesives, Coatings, and Sealers Div., 900 Bush Ave., St. Paul, Minn.

Circle 601 on Page 19

Small Servo Motor

Model 8 SM 461 Size-8 servo motor is presented in new data sheet. Sheet lists features of the motor, shows dimensional outline drawings and torque-speed curves for the unit. In addition, construction features are delineated, and all principal electrical and mechanical characteristics are provided. 4 pages. Beckman Instruments Inc., Helipot Div., 2500 Fullerton Rd., Fullerton, Calif.

Circle 602 on Page 19

Recording Oscillograph

Type 5-123 recording oscillograph is illustrated in Bulletin 1623. Rack-mounting oscillograph is designed for maximum reliability, flexibility, ease of installation, operation, and maintenance. It provides visible records up to 60 times faster than any other print-out process. Bulletin pictures and describes each module in the unit, and list of specifications is included. 8 pages. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

Circle 603 on Page 19

Switches and Thermostats

Twenty representative Klixon precision-switch packages and twenty thermostat packages are shown in photographs and dimensional drawings in two new technical bulletins, designated PRSW-10 and THSN-26A, respectively. Typical configurations illustrate packaging facility in the design and production of custom switch actuators, custom temperature controls, and special-design configurations to meet special application needs. 8 pages. Texas Instruments Inc., Metals & Controls Div., Spencer Products Group, 34 Forest St., Attleboro, Mass.

Circle 604 on Page 19

Silicones in Appliance Design

How silicones aid appliance design, performance, and manufacture is the subject of Brochure 1-116. "Extra Edge for Extra Sales" describes practically all known appliance uses for silicone rubber, paints, fluids, lubricants, and electrical insulation. It includes photographs, tables, and graphs to illustrate how silicones aid in providing long, maintenance-free service by improving mechanical dependability and electrical reliability. 8 pages. Dow Corning Corp., Midland, Mich.

Circle 605 on Page 19

Sequence Programmer

Bulletin 360 describes MSP-1 sequence programmer, used for precise timing and cycling of automatic work operations with air or electricity. Photograph and line drawings are provided, as well as a list of construction features. Information on cams and accessories is also furnished. Clippard Instrument Laboratory Inc., 7390 Colerain Rd., Cincinnati 39, Ohio.

Circle 606 on Page 19

Seamless Strip-Tubing

Strubing, a new seamless light-wall tube produced in most metals, is described in two-color, pocket-size brochure. Material is processed in strip form and rolled up for compact shipment. Brochure, which outlines the economies of packing, shipping, and storing of the tubing, explains how mechanical techniques are used to expand the strip into tubular form, the alloys which are presently being worked on, method of fabrication, and size range. 8 pages. Calumet & Hecla Inc., Wolverine Tube Div., 17200 Southfield Rd., Allen Park, Mich.

Circle 607 on Page 19

AC Motors

Line of small ac special-application motors, offering 16 horsepower ratings from 1/100 to 1/3 hp, is described in Bulletin 445. Bulletin lists construction features, ratings, and dimensions of 32 specific models. Different models result from a choice of four frame sizes, three types of mounting, three pole speeds, and four types of motor design. Tables list all specifications. 8 pages. Robbins & Myers Inc., Fractional Horsepower Motor Div., Springfield, Ohio.

Circle 608 on Page 19

Molded Coil Bobbins

Precision-molded coil bobbins available from stock and to specification are described in Bulletin 3003. It offers detailed information on the engineering properties of thermoplastics used—nylon, Delrin, Kel-F, and Genetron—to help select the best material for a particular application. Table on the electrical characteristics of nylon is included. Cut-away drawing shows design features of the bobbins. 2 pages. Gries Reproducer Corp., 400 Beechwood Ave., New Rochelle, N. Y.

Circle 609 on Page 19

Coatings Selector

New selector is a guide to the selection of specialty coatings available for application on plastics, metals, glass, and wood. Charts, which can be mounted for ready reference, show the uses and characteristics of spray, dip, and flow-coating materials, vacuum-metallizing coatings, and standard plastisol formulations. Bee Chemical Co., Lansing, Ill.

Circle 610 on Page 19

Clutches and Differentials

Pocket-size Catalog 63 presents complete line of magnetic clutches and precision differentials. Line drawings and all specifications are provided for each of the various units. 50 pages. Sterling Precision Corp., Instrument Div., 5 Sintsink Drive E., Port Washington, L. I., N. Y.

Circle 611 on Page 19

Power Transmission

Bulletin 23103 lists information on mechanical power-transmission equipment including bearings, bushings, flexible couplings, motor bases, pulleys, rigid couplings, timing-belt drives, adjustable-speed drives, and V-belt drives. All units are pictured and described, with size information provided. 8 pages. T. B. Wood's Sons Co., Chambersburg, Pa.

Circle 612 on Page 19

Fabrication of Teflon

Bulletin SM-100, "Custom and Standard Fabrication of Teflon," provides many photographs of fabricated Teflon parts. Chart lists mechanical properties of molded Teflon TFE resins used. 6 pages. Sparta Mfg. Co., Dover, Ohio.

Circle 613 on Page 19

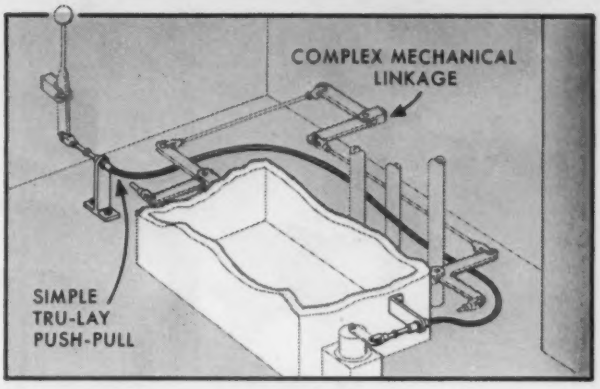
Industrial Clamps

Revised Catalog 1-103 offers extensive information on clamps for hose, plastic pipe, and varied industrial applications. Variety of clamps available is shown in photographs and detailed dimensional drawings. Helpful information includes construction details and specific recommended uses. Comprehensive statistical data on minimum and maximum clamp diameters, hose diameters, band and screw lengths, where applicable, are listed in tabular form. 4 pages. Ideal Corp., 435 Liberty Ave., Brooklyn 7, N. Y.

Circle 614 on Page 19

TRU-LAY *PUSH-PULL* CONTROLS PROVIDE ACCURATE, DEPENDABLE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

• If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over long or short distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



Sizes and Operating Heads to Fit Your Design

Control Dimension	Minimum Recommended Radius in Inches	Maximum Input Load in Pounds (Dependent on Travel)
3/32"	2	30
1/8"	3	65-125
3/16"	5	115-175
1/4"	6	300-600
5/16"	8	700-1,000

Heavy Duty • For use where rugged duty prevails, but where operation must be smooth and accurate. Meets all requirements for dependability and life.

Light Duty • Gives smooth, accurate and dependable performance at low cost. Available with your choice of several types of knobs.

Selective Friction • Amount of friction can be changed to meet individual requirements of the operator or application. Friction constant at any setting.

Position Lock • A slight turn of the T-type handle locks the control in any position. Available in two sizes for light and heavy-duty applications.

Micro Control • Push or pull the knob for instantaneous response, then rotate knob for vernier adjustment. Built for smooth, efficient operation on any job.

PUSH-PULL DATA FILE shows how to simplify, improve design

PUSH-PULL CONTROLS are solid as a rod and flexible as a wire rope. They're factory-lubricated for life, unaffected by temperature extremes, and can be adapted to practically any application. For complete details on how you can use them, write for the PUSH-PULL DATA FILE. It contains 7 engineering Bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages. Our engineers will be glad to help you make TRU-LAY PUSH-PULL CONTROLS a part of your product.

PUSH-PULL CONTROLS

Automotive and Aircraft Division • American Chain & Cable Company, Inc.

601-A Stephenson Bldg., Detroit 2

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ACCO

Circle 489 on Page 19

Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD-66av.

DUFF-NORTON COMPANY
Four Gateway Center • Pittsburgh 22, Pa.

COFFING HOIST DIVISION • Pittsburgh, Pa.

DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

COFFING HOISTS
Ratchet Lever • Air
Hand Chain • Electric

Circle 490 on Page 19

HELPFUL LITERATURE

Screw Threads

Illustrated "Harper Thread Guide" offers a basic introduction to the varied types of threads. Diagrams are used to explain the differences between the major kinds of screw threads. Charts detail measurements, characteristics, and capabilities of standard thread types according to Unified and American Thread Series, ASA B 1.1-1960. Additional charts describe characteristics and other data of tapping screws and wood screws. Torque guide outlines normal load values that can be applied to bolts of various metals. 16 pages. H. M. Harper Co., 8200 LeHigh Ave., Morton Grove, Ill.

Circle 615 on Page 19

Magnifying Comparator

New pocket-sized folder describes in detail a magnifying comparator for the measurement and comparison of miniature parts and assemblies. Five new reticles have been added to the fifteen formerly available for use with the comparator. Features and applications are listed, and reticles are pictured and described briefly. 10 pages. Finescale Co., 218 S. Western Ave., Los Angeles 4, Calif.

Circle 616 on Page 19

AC Motors

Product Data Catalog 107-2 describes ac motors designed to meet the requirements of government specifications for aircraft and missiles. Motors are designed for application on electromechanical linear and rotary actuators, servos, pumps, and valves. Catalog presents information on horsepower, torque, speed, duty cycle, weight, and size. 6 pages. Lear Inc., P. O. Box 688, Grand Rapids 2, Mich.

Circle 617 on Page 19

Nickel-Chromium Alloy

Bulletin 110 contains detailed technical data on Chromel-AA, a new modified 80-20 nickel-chromium resistance alloy developed for use as heating elements in controlled-atmosphere furnaces. Information presented includes a table of physical properties, typical life and temperature-resistance curves, and test data. Also included are complete specification tables and formulas to facilitate conversion of existing atmosphere furnaces to Chromel-AA. 8 pages. Hoskins Mfg. Co., 4445 Lawton Ave., Detroit 8, Mich.

Circle 618 on Page 19

Window Units

Three types of versatile window units are described in three-color Bulletin 8-E. Fully described and illustrated are level-type, standard-type, and open-type units. Typical applications are given for each unit available. Diagrams of units are provided, along with specification charts with listing of part numbers and sizes. Installation data are also provided. 4 pages. Bijur Lubricating Corp., Rochelle Park, N. J.

Circle 619 on Page 19

Tenzaloy revolving chair base is a lightweight, high strength part that readily takes a desirable finish—anodizes clear white and takes a brilliant polish.

Sharp detail, brilliant finish, high strength castings:

TENZALOY

SELF-AGING ALUMINUM ALLOY

Tenzaloy, the aluminum alloy that needs no heat treatment, offers finished properties with great promise to the designer. Castability, even in complex shapes, is excellent. Castings are sharp, clean, take brilliant polish, anodize clear white, can be dyed all available colors, bright or pastel. Tenzaloy has great strength in thin cross sections, superior corrosion resistance, high dimensional stability. Investigate Tenzaloy for your new product. Write for Bulletin No. 103, or call Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, REctor 2-9500; or call your nearest Federated sales office.

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

FEDERATED METALS DIVISION

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St. Louis: Jackson 4-4040

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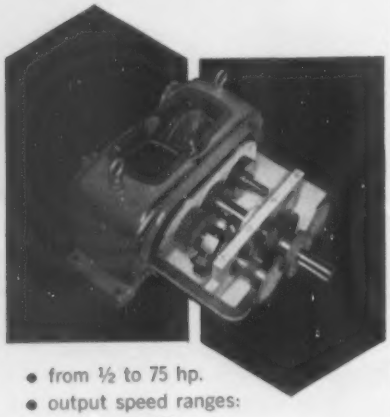
Circle 491 on Page 19

Specify
SPECON for
VARIABLE
SPEED
DRIVES
electrical and mechanical



- from ½ to 75 hp.
- output speed ranges: 0-100 to 0-7000 rpm
- smoothly adjustable through zero speed
- draw accuracies of .01%
- full torque at zero speed

These are just some of the outstanding characteristics of Specon variable speed drives. Rugged, reliable and requiring minimum maintenance, they permit infinitely fine adjustment of output speed with accuracies approaching fixed gearing. Specon drives also feature shockless starts and acceleration, full reversing, and provide output speeds up to 7000 rpm while maintaining zero speed features.

Send for FREE data booklet on Specon variable speed drives.

STRATOS
A DIVISION OF FAIRCHILD ENGINE & AIRPLANE CORPORATION
INDUSTRIAL PRODUCTS BRANCH
#42, Route 109, West Babylon, N. Y.

Circle 492 on Page 19

HELPFUL LITERATURE

Speed Reducers

Catalog HM 60 contains engineering data, mounting information, service factors, horsepower, torque, and overhung load ratios for seven models of HM horizontal motorized differential speed reducers. Tables and line drawings are used to illustrate and describe the units, which offer a ratio range of 1:1.1 to 50,000:1. 16 pages. Winsmith Inc., 6 Elton St., Springville, Erie County, N. Y.

Circle 620 on Page 19

Steel Tubing and Bars

Technical bulletin contains weight comparison tables for welded-steel tubing and solid bars. It also includes useful tables of drive-shaft torque values, physical properties, and available sizes of welded-steel tubing. Strength and ductility values are tabulated for as-welded, normalized-drawn, and mandrel-drawn tubing. 4 pages. Standard Tube Co., Michigan Steel Tube Products Div., 24400 Plymouth Rd., Detroit 39, Mich.

Circle 621 on Page 19

High-Temperature Fasteners

Bolts, screws, nuts, and dowels for effective elevated-temperature use are described and illustrated in Engineering Data Catalog 286. Units are fabricated to AMS 5735 for 1300 to 1800 F applications. Line drawings and all specifications are provided. 12 pages. Mercury Air Parts Co. Inc., 9310 W. Jefferson Blvd., Culver City, Calif.

Circle 622 on Page 19

Screw Conveyor Drives

Bulletin 7106 presents details on new screw conveyor drives, available for applications from ⅓ to 30 hp (output torque to 21,400 lb-in.), in four ratios, designed to bolt to standard trough ends. Design features and accessories are described. Technical data includes selection and dimension information, NEMA motor dimensions, and nominal sheave ratios for typical unit ratios and conveyor speeds. 20 pages. Falk Corp., Dept. 255, Box 492, Milwaukee 1, Wis.

Circle 623 on Page 19

Steel Pipe

Data Chart Sec. F, No. 7, covers the dimensions and weights of steel pipe. Fourteen different schedules are shown, in range from ⅛ to 30-in. pipe size. Data for stainless pipe are shown where the wall thickness specified for stainless differs from that of carbon pipe. Table showing the capacity of round tanks in diameters to 32 ft 9 in. is provided, with an explanation for determining the capacity of larger tanks. Formulas for calculating capacities of rectangular and elliptical tanks are also included. Chart is printed on cardboard stock, 8½ x 11 in. in size, three-hole punched, and tabbed. Peter A. Frasse & Co. Inc., 17 Grand St., New York 13, N Y.

Circle 624 on Page 19

A new pump concept "integral design" saves both cost and space for machine designers

The development of three low cost elements ready to build into the housing of any mechanism requiring a pumping function eliminates the purchase of complete pumps. *(Fig. 1.)*

Fig. 1. Three Gerotor components permit pump to be incorporated as integral part of housing or frame of mechanism, eliminate need for purchase and mounting of separate, complete pump.

Mounting pads, couplings, connectors and accessory drives are done away with by this progress in design. Consisting of an inner and outer Gerotor and an eccentric locator-ring, the unit becomes a complete pump by simply through-boring the casting or frame of the mechanism to accommodate the locator ring. O. D. and to provide porting. This design makes the main casting do double duty as the pump housing, thus eliminating a very considerable cost factor. A drive can be taken from any convenient shaft.

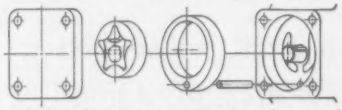
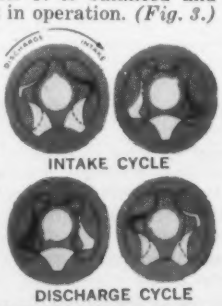


Fig. 2. Nichols integral pump-package is as easily installed as an anti-friction bearing.

The matched elements are thus as easily built-in as a simple anti-friction bearing would be. Further, the Gerotor pump is extremely flexible in its configuration and readily adapts to a wide variety of mechanism geometries. It will handle a variety of fluids at rates up to 100 gpm and pressures up to 1,000 psi.

The Gerotor pump is a positive displacement type, delivering a predetermined amount of fluid in direct proportion to speed. It is a form of internal gear pump — simple and compact in basic design, (has only two moving parts). It is lightweight, valveless, provides exceptional performance and has low wear over a long service life. It is balanced and extremely quiet in operation. *(Fig. 3.)*

Investigate this cost saving design advance. Technical assistance is available. We'll provide data from which you can fully evaluate the advantages to you. *(Fig. 3.)*



W. H. NICHOLS CO.
Woerd Ave., Waltham 54, Mass.

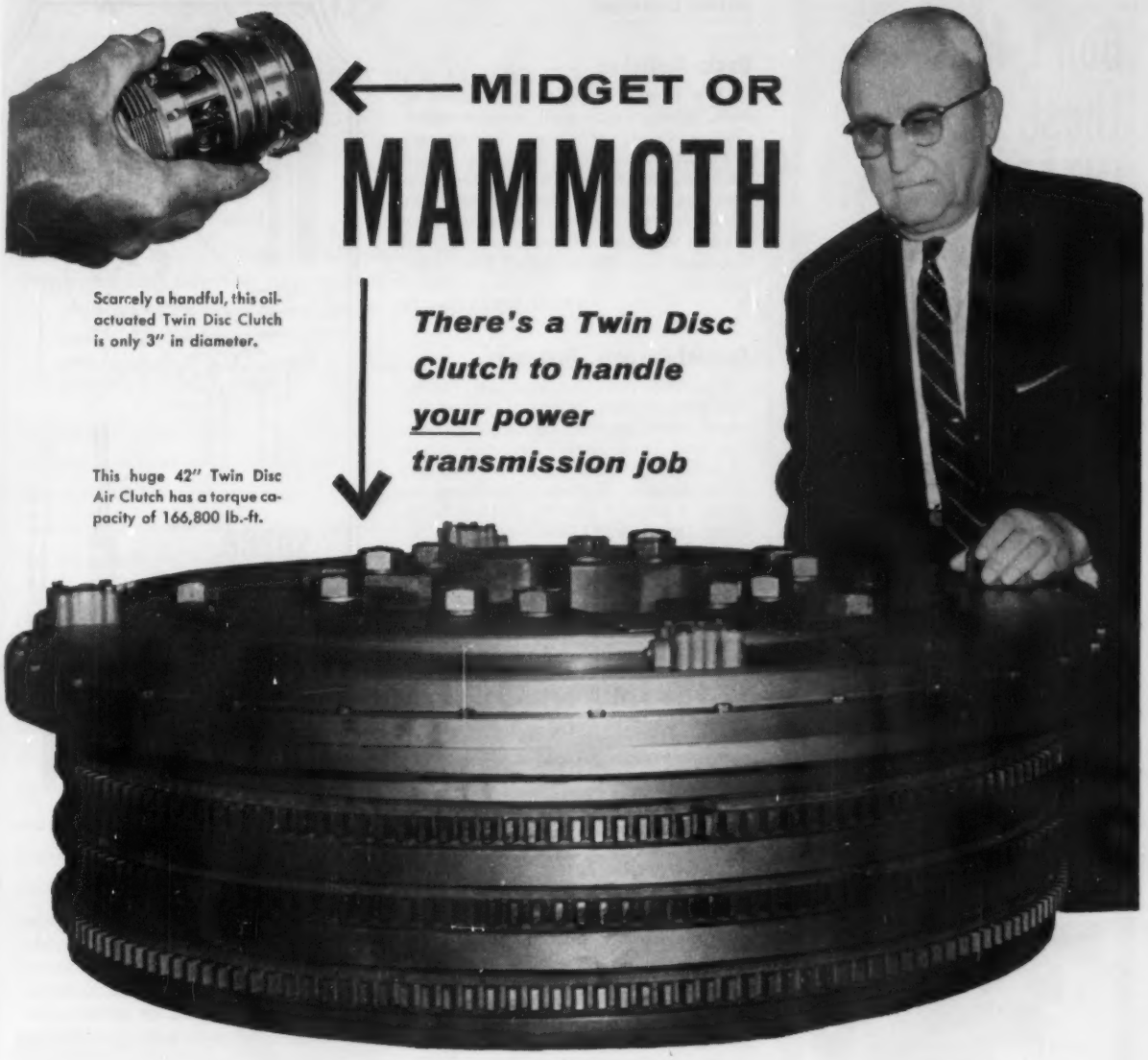
Circle 493 on Page 19

Scarcely a handful, this oil-actuated Twin Disc Clutch is only 3" in diameter.

← MIDGET OR MAMMOTH

There's a Twin Disc Clutch to handle your power transmission job

This huge 42" Twin Disc Air Clutch has a torque capacity of 166,800 lb.-ft.



MECHANICAL

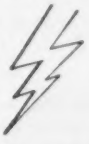
Small wet or dry clutches in 3.5" and 4.5" sizes with capacities to 14 hp. Enclosed units in sizes from 5.5" to 11.5" and capacities from 14 to 112 hp. Large heavy-duty clutches for high-torque duty; sizes to 36" and capacities to 1050 hp.

PNEUMATIC

Twin Disc Air Clutches provide more compact remote control without complicated linkage. Lighter weight reduces inertia mass, lessens shock loading during starting cycles. Sizes from 8" to 42" for every air-actuating application. Capacities from 29 to 1642 hp. Max. torque: 166,800 lb-ft.

HYDRAULIC

Oil-actuated multiple-plate clutches for high-speed, high-energy operation. Compactly designed, readily adapted to push button control. Available with optional integral oil collector. Sizes from 3" to 7". Capacities to 137 hp and 690 lb-ft. of torque.



ELECTRIC

Direct-acting wet-type electro-magnetic clutches with stationary coils. Annular flux-through-plates magnetic principle provides high torque capacity and compact design. Compensates automatically for wear. Sizes range from 3.3" to 11.5" with torque ratings from 14.5 to 1812 lb-ft.

Send for Bulletin 314

This 20-page bulletin gives details and specifications on the complete line of Twin Disc Friction and Fluid Drives. Write to TWIN DISC CLUTCH COMPANY, Racine, Wis.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC

Friction Clutches and Fluid Drives

Circle 494 on Page 19

Don't let these Devils INTERFERE with OPERATING PERFORMANCE

Troublesome maintenance and lubricating problems are eliminated when you specify Thomas "All-Metal" Flexible Couplings to protect your equipment and extend the life of your machines.

Like a thief in the night an inadequate coupling causes wear and damage to your machines — resulting in high maintenance costs and costly shut-downs.

NO MAINTENANCE
NO LUBRICATION
NO WEARING PARTS
NO BACKLASH

UNDER LOAD and MISALIGNMENT only THOMAS FLEXIBLE COUPLINGS *offer all these advantages:*

- Freedom from Backlash
- Torsional Rigidity
- Free End Float
- Smooth Continuous Drive with Constant Rotational Velocity
- Visual Inspection While in Operation
- Original Balance for Life
- Unaffected by High or Low Temperatures
- No Lubrication
- No Wearing Parts
- No Maintenance

Write for our New Engineering Catalog 60

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U.S.A.

Circle 495 on Page 19

HELPFUL LITERATURE

Basic Switches

Data Sheet 175 covers three series of basic switches with gold contacts which offer a variety of designs for mv ma dry-circuit switching appl'cations. Sheet includes photographs, mounting dimension drawings, mechanical characteristics, electrical ratings, terminal variations, and pricing. 4 pages. M'nneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill.

Circle 625 on Page 19

Special-Purpose Fasteners

Illustrated two-color brochure features four new concepts in special-purpose fasteners, including Pawl-Loc, Z'p-Loc, Pres-Loc, and blind rivets. Enlarged picture of each unit is given, along with examples for application. Features of each type are listed. 4 pages. Deutsch Fastener Corp., Dept. DF155, P. O. Box 61072, Los Angeles 61, Calif.

Circle 626 on Page 19

Gate Valves

Ductile iron gate valves are described in new bulletin. Full-page cross-sectional drawing is used to po'nt up the special features. Charts provide information on sizes and d'mensions, and pressure-temperature ratings. 4 pages. Crane Co., Industrial Produ-ts Group, 4100 S. Kedzie Ave., Chicago 32, Ill.

Circle 627 on Page 19

High-Strength Insert

Series of data sheets describes various models of Slimsert high-strength inserts. All engineering specifications are provided, including sizes, phys'cal properties, materials and finishes, and design capabilities. Information on installation and removal, and on tools necessary, is also included. 6 pages. Rosan Inc., 2901 W. Coast Highway, Newport Beach, Calif.

Circle 628 on Page 19

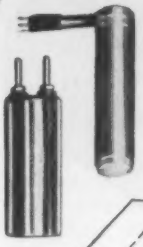
Relief Valves

Catalog FE-138 describes and illustrates complete line of safety-relief valves for general industrial service and other applications. Sizing information, capacity tables, weights and dimensions, and application data are arranged in a simplified format which makes valve selection easier. 28 pages. Farris Engineering Corp., 702 Commercial Ave., Palisades Park, N. J.

Circle 629 on Page 19

Military Components

Military Components Catalog 50A covers latest versions of specifications concerned with fixed and adjustable-power resistors, precision resistors, rheostats, tantalum capacitors, and relays. New categories of components have been added to the listings, such as etched tantalum-foil capacitors. Photographs and line drawings are included. 36 pages. Write on company letterhead to Ohmite Mfg. Co., 3679 Howard St., Skokie, Ill.



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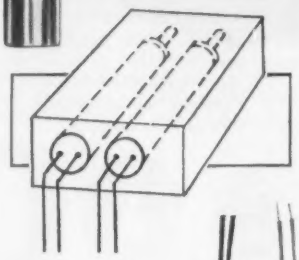

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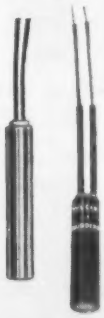


VULCAN CARTRIDGE HEATERS

Vulcan Cartridge Heaters are designed especially to provide concentrated heat in small areas by insertion into machine parts, dies, platens, molds, presses, die blocks of embossing machines, packaging machines, etc. There is practically no heat loss because the cartridge is completely surrounded by the metal or material to be heated.

Vulcan Cartridges are available in a wide choice of standard sizes — from 1″ to 25″ (or longer); diameter — 1/4″ to 1 19/64″ (or greater); sheath — brass, steel, nickel or high temperature alloys; full range of wattage and voltage ratings. The proven "Thunderbolt" Heater is available for extreme conditions of watt density and temperature.

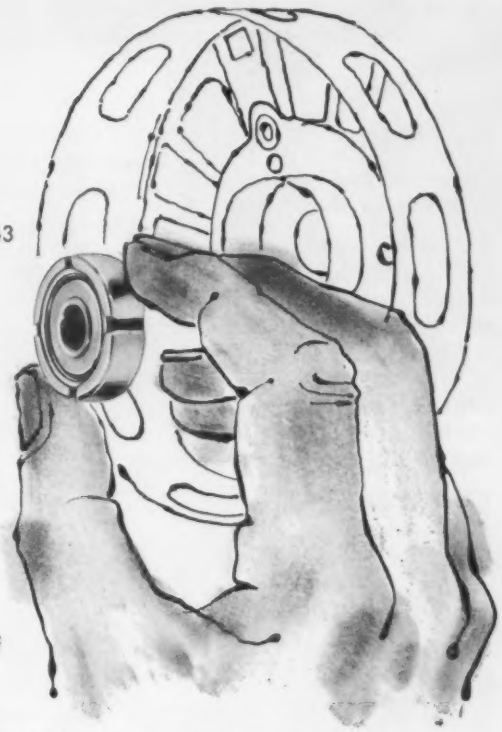
Write for catalog and prices.

VULCAN
Versatility in Electric Heating
VULCAN ELECTRIC COMPANY, Danvers, Mass.

Circle 496 on Page 19

New Motors by **UNIVERSAL** introduce new free-aligning ball bearing assembly*

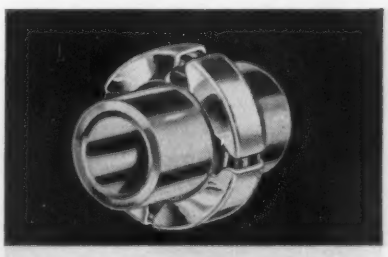
. . . utilizing only the shaft for alignment, the new Universal Ball Bearing Assembly provides:
. . . reduced noise level in ball bearing motors . . .
. . . easier starting regardless of load . . .
. . . elimination of pre-loaded bearings due to misalignment.



Two new UNIVERSAL ELECTRIC motors, Type 523 (4 pole) and Type 563 (6 pole) incorporate an entirely new ball bearing assembly design. The new ball bearing assembly is resiliently suspended in a neoprene collar with the axis of support in the center of the bearing. The bearing is thus inherently in balance and can adjust to any shaft misalignment 100% of the time utilizing only the shaft itself for alignment. This new design requires no pressure to retain the bearing in its position and the bearing cannot be forced from its seat regardless of the amount or type of load placed on the shaft.

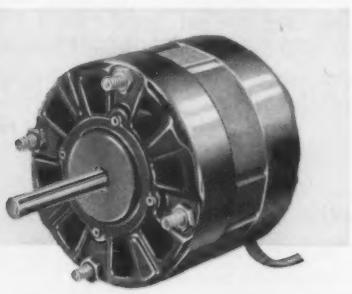
Advantages of the UNIVERSAL ELECTRIC ball bearing design are (1) reduced noise level, (2) permanent cushioned end play, (3) easier starting, (4) elimination of snap rings, shoulders and undercuts thus providing a stronger motor shaft and (5) elimination of preloaded bearings due to misalignment thus resulting in a free running motor with a longer motor life. UNIVERSAL offers the only ball bearing shaded pole motors on the market that can make all of these claims.

*Pat. applied for



Universal Bearings*

Universal Free-Aligning sleeve-type Bearings eliminate fractional HP motor bearing problems due to misalignment. Like the new ball bearing assembly, this revolutionary bearing is inherently in balance and can adjust to any shaft misalignment 100% of the time under any load condition.



UNIVERSAL Electric Motors type 523 and type 563 with the new ball bearing assembly, offer the perfect flat speed torque curve necessary for critical air moving or recorder applications. In addition to these 2 new motors, UNIVERSAL ELECTRIC also is making a new 6 pole sleeve bearing motor Type 63 as well as the standard 4 pole, Type 23. These motors offer maximum performance and efficiency for kitchen ventilators, unit heaters, evaporative coolers, condenser fans, refrigerated cabinets, etc.

Write for complete specifications on your requirements.

55

UNIVERSAL ELECTRIC COMPANY

PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 10

Circle 497 on Page 19

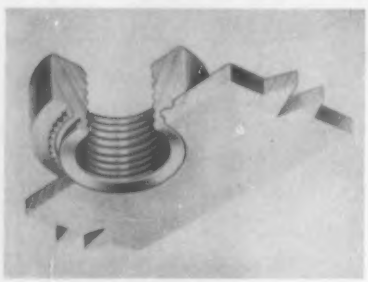
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Press-In Nut

provides load-bearing threads for sheet metal

Inexpensive method of obtaining load-bearing threads for later bolt or screw fastening in thick or thin ductile sheet metal is accomplished using the P-37 P-Nut. The press-in type unit is available for the airframe, electronic, and commercial industries. Locking serrations at base of nut provide a liquid-tight



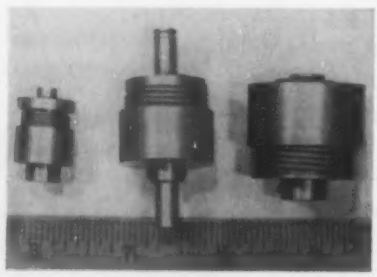
seal between nut and walls of drilled hole. Configuration of serrations produces excellent push-out and torque-out values. Tensile strength exceeds that of a 200,000-psi bolt. Nuts are available in coarse and fine threads in sizes from No. 4-40 NC to No. ½-20 UNF. **Hi-Shear Rivet Tool Co.**, 2600 W. 247th St., Torrance, Calif.

Circle 630 on Page 19

Slip Clutches and Brakes

are spring wrapped

Spring-wrapped slip clutches and brakes are designed for continuous slip. Element producing slip is a stepped spring. Inside diameter of the small step fits tightly in the bore of the output drum. Rotation of the shaft in one direction causes the coils in contact with the input to grip tightly, and the coils inside the output bore to contract and produce slip. Rotation in the opposite direction reverses the action



of the spring parts and slip is effected on the input drum. Limit torque ranges vary from a fraction to 48 oz-in. Limit torques can have the same or different magnitudes for the two directions of rotation. Standard units can be furnished with limit-torque ratios to 10:1. Limit torque is constant, and is precisely calibrated, with tolerance on standard units of ±15 per cent. Slip elements withstand continuous slip at respective power-dissipation ratings for a minimum of 500 hr of operation. Slip elements are corrosion resistant. Servo mechanisms and tensioning drives for film and tapes are typical applications for the slip elements. **Machine Component Corp.**, Gazza Boulevard, Farmingdale, N. Y.

Circle 631 on Page 19

Servo Amplifier

performs under severe environmental conditions

Tiny servo amplifier is suitable for use in computing instruments

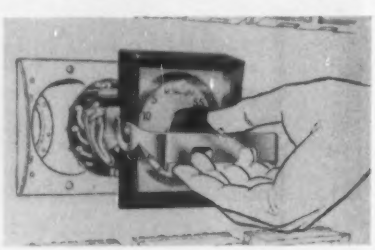
and in other applications requiring an amplified signal for driving a 400-cps instrument servo motor. Module is contained in a package with a total volume of less than 1 cu in. Amplifier features a choice of phase-shift characteristics, externally adjustable gain, and low output impedance with respect to load impedance. Amplifier performs reliably throughout a temperature range of −55 to +100 C, and has passed MIL-E-5272 specification covering temperature, altitude, shock, vibration, and humidity extremes. Amplifier withstands 10 g to 500 cps. It operates from any standard airborne 27-v dc power supply. **Lear Inc.**, Box 688, Grand Rapids, Mich.

Circle 632 on Page 19

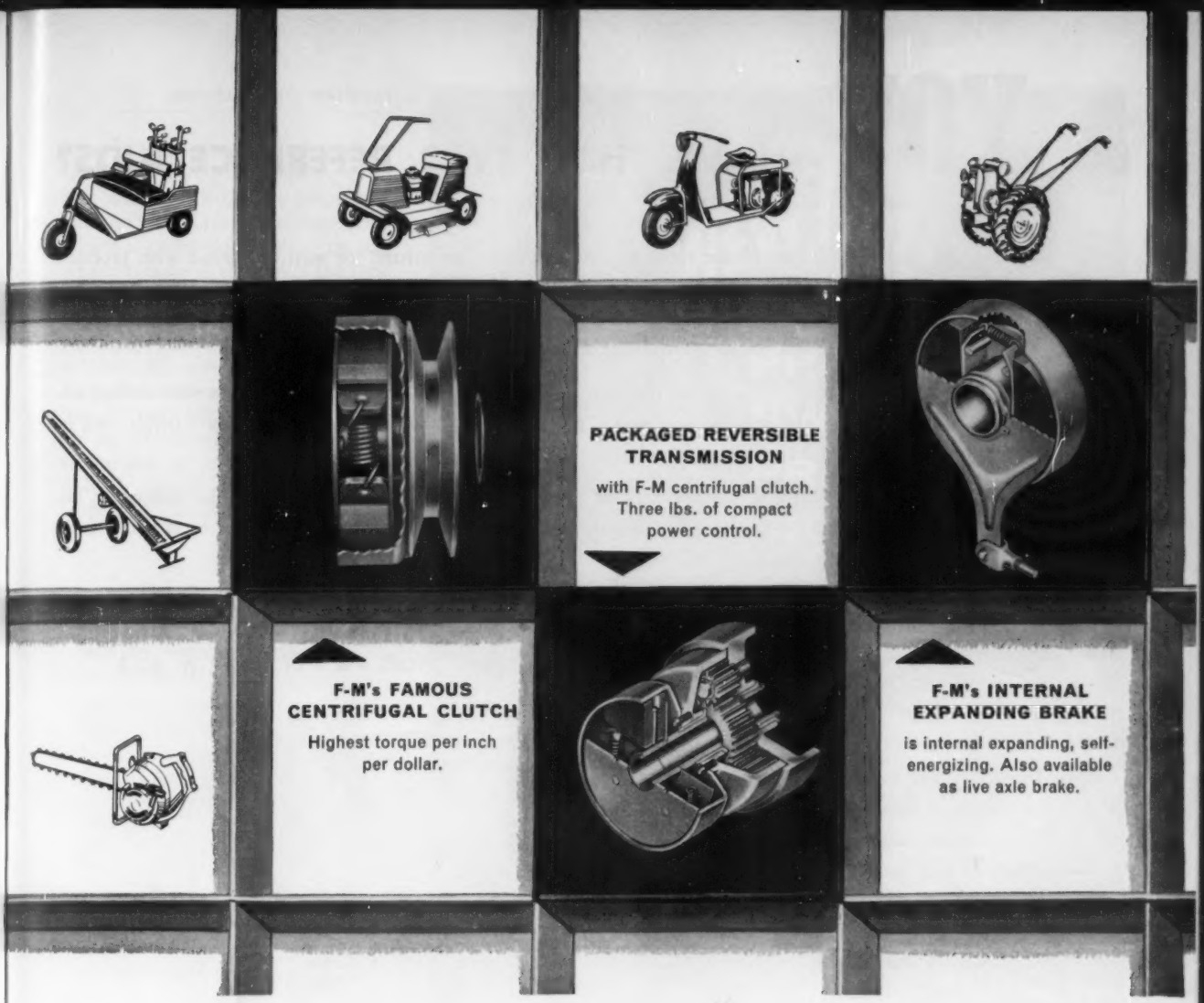
Reset Timer

has permanently mounted, plug-in case

Plug-in Cycl-Flex reset timer is furnished complete with its own plug-



in case, permanently mounted and wired to the application. Designed primarily for flush mounting, case can be installed by cutting one 3⅛-in. diam opening. All terminals and wiring information are conveniently located on the rear of the timer case. Timer itself can be removed and replaced from permanently mounted case at any time in 5 sec or less. Unit features its own handle/lock to insure a positive dust, oil-resistant seal. Timer con-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with F-M centrifugal clutch. Three lbs. of compact power control.
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Highest torque per inch per dollar.
F-M's INTERNAL EXPANDING BRAKE
is internal expanding, self-energizing. Also available as live axle brake.

Control Small Engine Power

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Circle 498 on Page 19

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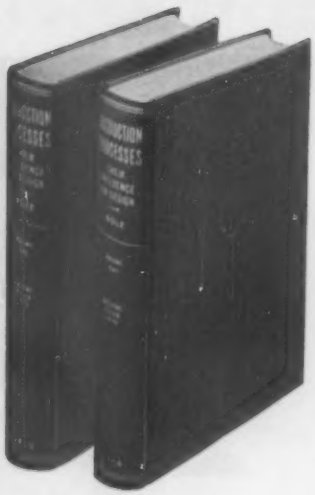

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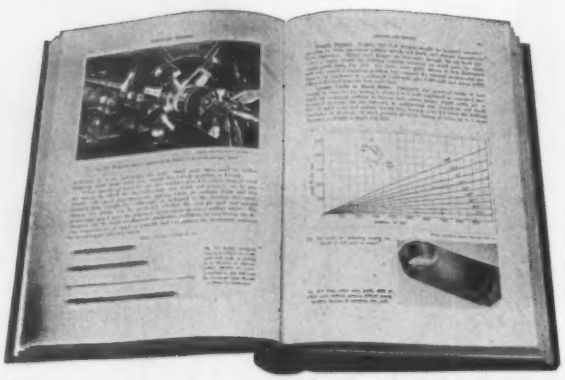

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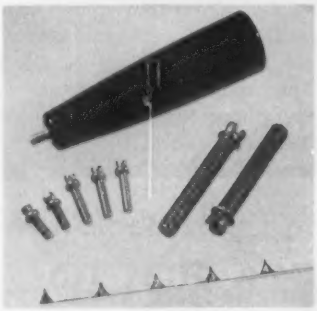
tains four separate and independent load contacts, two of which are instantaneous and can be considered and used as relays in circuitry. Two others are time-delay relay contacts which operate at the end of the time set on the dial. Each load contact, being separate and independent of the other, provides hundreds of practical control combinations. Two time-delay-relay contacts feature built-in adjustment to provide for an additional timed differential at the end of the time interval, as needed. **Eagle Signal Co. Div., Gamewell Co.**, 202 20th St., Moline, Ill.

Circle 633 on Page 19

Collar Insert

provides nonslip handle for electrical appliances



Split-head collar insert for plastics is stainless steel, molded into the plastic with threaded and extended. Molding of insert to plastic housing increases holding power of finished fastener. Unit assures improved, nonslip handle for electrical appliances. Fastener is particularly suitable for plastic knobs and handles, and is available in sizes from No. 6 through $\frac{3}{8}$ in. It is nonbreakable, nondeforming, heat and corrosion resistant, with threads that neither seize nor gall. **CSM Screw Products Co.**, 2105 Southport Ave., Chicago 14, Ill.

Circle 634 on Page 19

Directional Valves

for use with consoles or control panels

Panel-mounting directional valve design combines versatility and low cost with streamlined appearance for use with consoles or control panels. Single-unit valves are nor-

another fine product by

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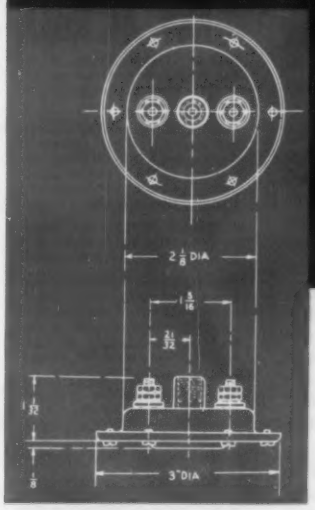

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Circle 500 on Page 19

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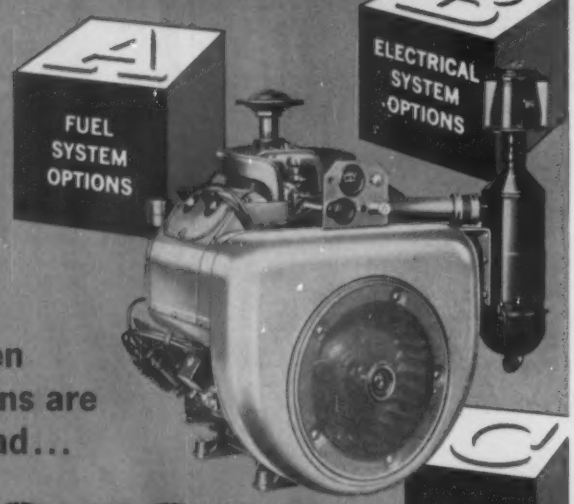

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OTHER ACCESSORIES — automotive and spark-arresting mufflers, pre-cleaners, drive pulleys for flywheel, rewind starters for ACN and BKN engines, and others.

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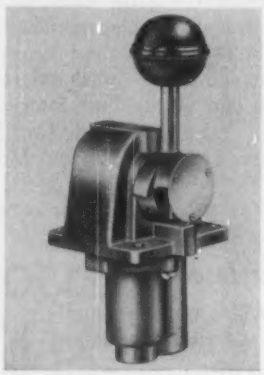
mally closed or normally open for three-way operation. Double-unit valves provide three types of four-way operation. An all-purpose operating cam can be rotated to change operation from one function to another. Essentially diecast zinc for corrosion resistance, they contain hardened, sintered steel cams.



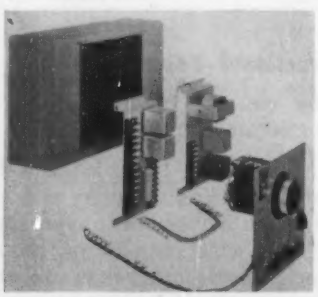
Seals and seats are oil-resistant synthetic rubber. Units are suitable for 250-psi maximum air pressure and temperatures from −40 to +200 F **Industrial Products Div., Westinghouse Air Brake Co.**, Wilmerding, Pa.

Circle 635 on Page 19

Adjustable-Speed Drives

have modular relay, rectifier, and control panels

Relay panels, rectifier panels, and control panels are designed as individual units and mounted separately in a compact enclosure in Series 35 electrical adjustable-speed drives. Modular construction (shown) permits prewiring and prestocking of a wide variety of chassis to meet different specifications. Drives are dc-motor types employing adjustable autotransformers in combination with full-wave rectifiers to attain infinitely variable speed adjustments over a wide



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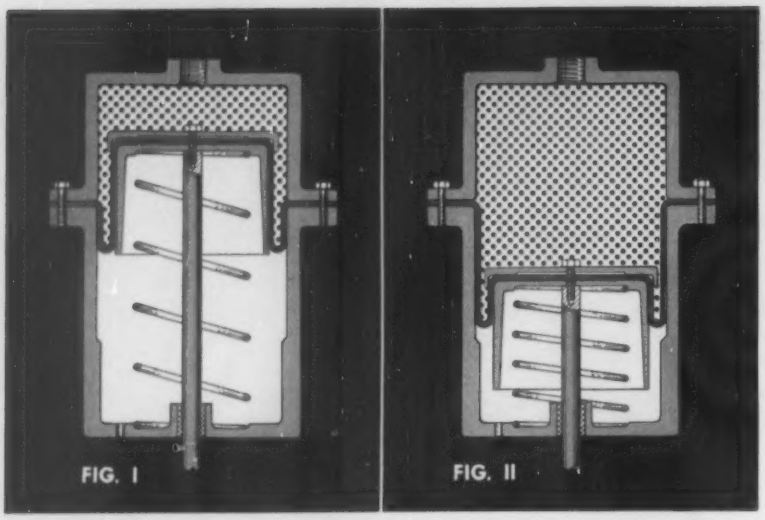
Circle 502 on Page 19



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Nothing rolls like a Bellofram® Rolling Diaphragm. It's frictionless!

The Bellofram Rolling Diaphragm provides ultrasensitive response in hydraulic or pneumatic devices where frictionless, long-stroke action in small-diameter configurations is required . . . and where flex life of millions of cycles is necessary.

These desiderata are achieved through the *rolling* action of a flexible thin-sidewall diaphragm consisting of a high-tenacity fabric overlay embedded in elastomeric material.

Fig. I shows how Bellofram Rolling Diaphragm conforms to the piston. Fig. II shows how, as the piston descends under pressure, the diaphragm *rolls* off the piston's sidewall and onto the cylinder's sidewall in a smooth, continuous, frictionless movement.

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9. Automatic de-icing action.
10. Free positioning with complete relaxation at any point in its stroke.
11. Does not require close machine finish tolerances on pistons and cylinders.
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14. Excellent temperature stability, from —85°F. to 550°F. (from —120°F. to 700°F. in some cases).

Wide range of working pressures: 1 in. H_2O to 500 psi (up to 1200 psi in some cases).

Effective pressure areas from .028 to 108 sq. in.

Cylinder bore diameters from .25 to 12 in.

Extended range of stroke (.01 to 12 in.).

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BRowning 2-2100 Mission 3-9000

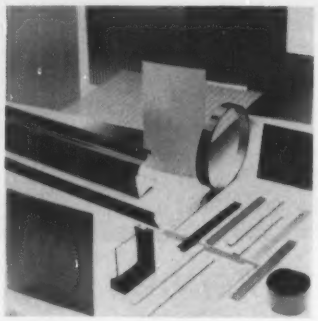
range. They are available in Size 1 for $\frac{1}{3}$ hp max, and Size 2 for $\frac{3}{4}$ hp max. Two other sizes are offered with maximum ratings to 10 hp. **Cleveland Machine Controls Inc.**, 1155 Brookpark Rd., Cleveland 9, Ohio.

Circle 636 on Page 19

Color-Coated Stainless Steel

is durable and corrosion resistant

ColorRold stainless steel, developed from a complex organic coating formula, combines durability and corrosion resistance of stainless steel with the versatility of color harmony. Colored stainless provides good toughness, weathering, and



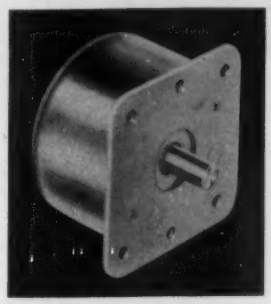
fabricating characteristics. It can be sheared, bent, formed, and drawn to extreme degrees without damage to the color coating. Ordinarily supplied as a solid, color-coated metal, it can also be embossed or textured. Ten standard colors and white maintain high degree of color fidelity. Stainless is available in coil or sheet form to 48 in. wide in all popular gages. **Product Development Dept., Washington Steel Corp.**, Washington, Pa.

Circle 637 on Page 19

Stepping Motor

has high torque-to-size ratio

Compact, reliable unidirectional Digimotor has long life and high torque-to-size ratio. Quiet, jamproof operating mechanism is completely enclosed in a protective housing, has a magnetic anti-overcoast, and is permanently lubricated. Stepping rate is 15 to 25 steps per second, depending on positions, load, and other factors. Digimotor has many



applications, and can be used as an efficient power source for driving potentiometers, counters, rotary switches, tape advance, and a variety of control mechanisms. It can also be used to operate gear trains, indicators, valves, and cams. Thirty models are available from stock, with or without detent, in 8, 10, 12, 18, 20, and 24 steps per revolution. **Ledex Inc.**, 123 Webster St., Dayton 2, Ohio.

Circle 638 on Page 19

Epoxy Adhesive

bonds nylon to nylon

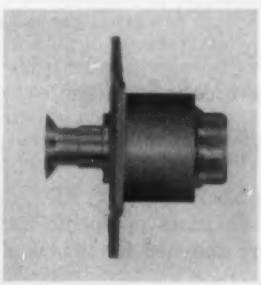
Two-component, 100-per cent solids epoxy adhesive, Hysol 4219, bonds nylon to nylon at room temperature. Easy surface preparation consists of roughening with emery cloth and wiping with acetone. Adhesive is not affected by immersion in JP4, alcohol, or high-flash naphtha. **Adhesives and Sealants Dept., Hysol Corp.**, Olean, N. Y.

Circle 639 on Page 19

Panel Fastener

accomplishes locking by four locking balls

Quick-release panel fastener that mounts flush with panel surface offers positive locking, instant release, and good strength characteristics. Locking is accomplished by four locking balls, using no threads,



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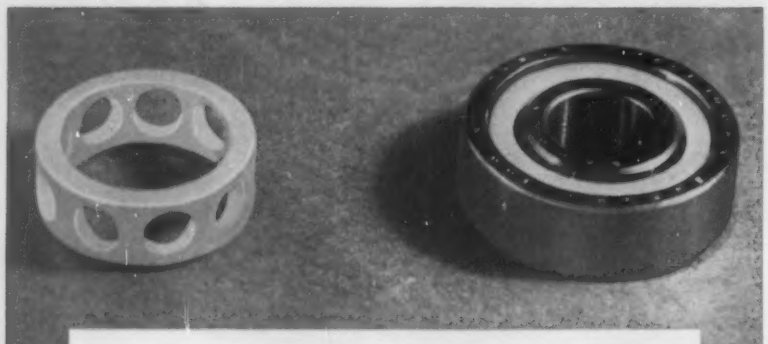
Smooth Power
AC MOTORS
1/1800 H.P. to 1/35 H.P.
Catalog Available On Request
THE GENERAL INDUSTRIES CO.
DEPT. 6K • ELYRIA, OHIO

Oil-filled **NYLASINT**® parts retain lubricant while spinning at 1000 Gs



Ball bearing retainers of oil-filled "micro-porous" Nylasint will not bleed under extremes of temperature, pressure and acceleration.

These permanent built-in lubrication properties of Nylasint sintered nylon were demonstrated on ball bearing retainers (above) which operated over 10,000 hours under severe load conditions with no additional lubrication . . . and without loss in performance.

Micro-porous Nylasint parts absorb and retain fluids up to 50% by weight to minimize friction in bearing and wear applications. Almost 20% of the initial oil is retained at 15,000 Gs.

As an ink-filled roller, Nylasint has all the desirable mechanical surface characteristics of nylon while holding a large amount of ink which can be fed uniformly.

Inert fillers also can give resilient Nylasint parts outstanding dimensional stability and high load capacity . . . important for such diverse fields as missile components and steel office furniture.

For complete technical data on Nylasint, call or write for new Nylasint Bulletin BR-1111.

POLYPENCO

INDUSTRIAL PLASTICS

Halex Corporation

a subsidiary of The Polymer Corporation

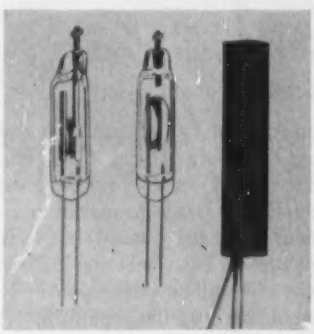
Reading, Pa.

nuts, or cotter keys. Fastener consists of a stud permanently attached to the panel, and the receptacle mounted on the chassis or framework of the assembly. When stud is seated in the retainer it is locked. Release is a quick, automatic spring ejection of the stud, allowing panel to be removed without prying. Fastener is automatically spring-ejected if not fully seated. Fastener can be used on flat surfaces or curved surfaces as small as a 9-in. radius. It is available in normal duty ¼-in. diam and heavy duty 5/16-in. diam. Three grip lengths accommodate panel thicknesses from 0 to ⅛, ⅛ to ¼, and ¼ to ⅜ in. **Avdel Inc.**, 210 S. Victory Blvd., Burbank, Calif.

Circle 640 on Page 19

Mercury Switch

low-cost unit replaces two switches



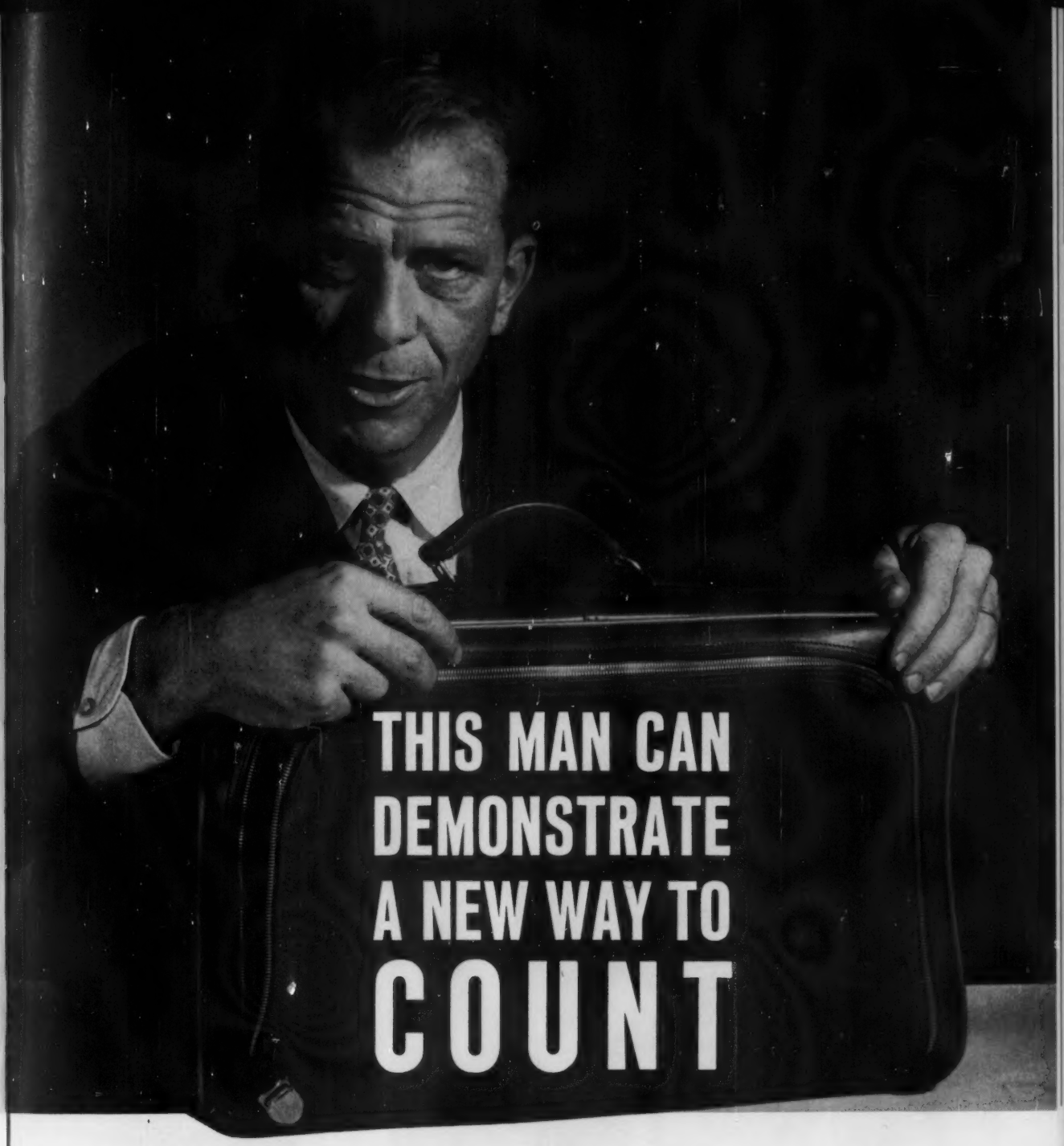
Low cost SPDT mercury switch is capable of replacing two mercury switches in such applications as vending machines, programmers, annunciators, interlocks, and alarm systems. Switch is available in two models: HG 900 LO has break-before-make action, and HG 901 LO has make-before-break action. Both switches are also available in a shockproof, waterproof, potted package. Package dimensions are 0.400 in. diam by 1¾ in. long. **Gordos Corp.**, 250 Glenwood Ave., Bloomfield, N. J.

Circle 641 on Page 19

Pillow-Block Bearings

for light and medium-duty service

Pillow-block bearings, EDX Series, utilize housings of ductile material and are designed for light and me-



. . . right in your own office!

Fifteen minutes of your time — that's all it'll take to put on the Veeder-Root "DESK-TOP DEMONSTRATION" — an actual performance of how Veeder-Root Electronic Counters will improve your production records, improve your product. Let us show you how Veeder-Root Electronic Counters can measure quantities, lengths, liquids; count odd-shape objects; actuate machinery; measure batches. Let us show you new counting methods utilizing Electronic Counters to count, measure, actuate — rapidly, accurately, from remote locations, with complete flexibility, with minimum maintenance.

Make sure you see the Veeder-Root "DESK-TOP DEMONSTRATION". Just call your nearby Veeder-Root branch office or write direct. Your Veeder-Root sales engineer will be glad to put on the demonstration at your convenience.

Veeder-Root

ELECTRONIC CONTROLS DIVISION
DANVERS, MASS.

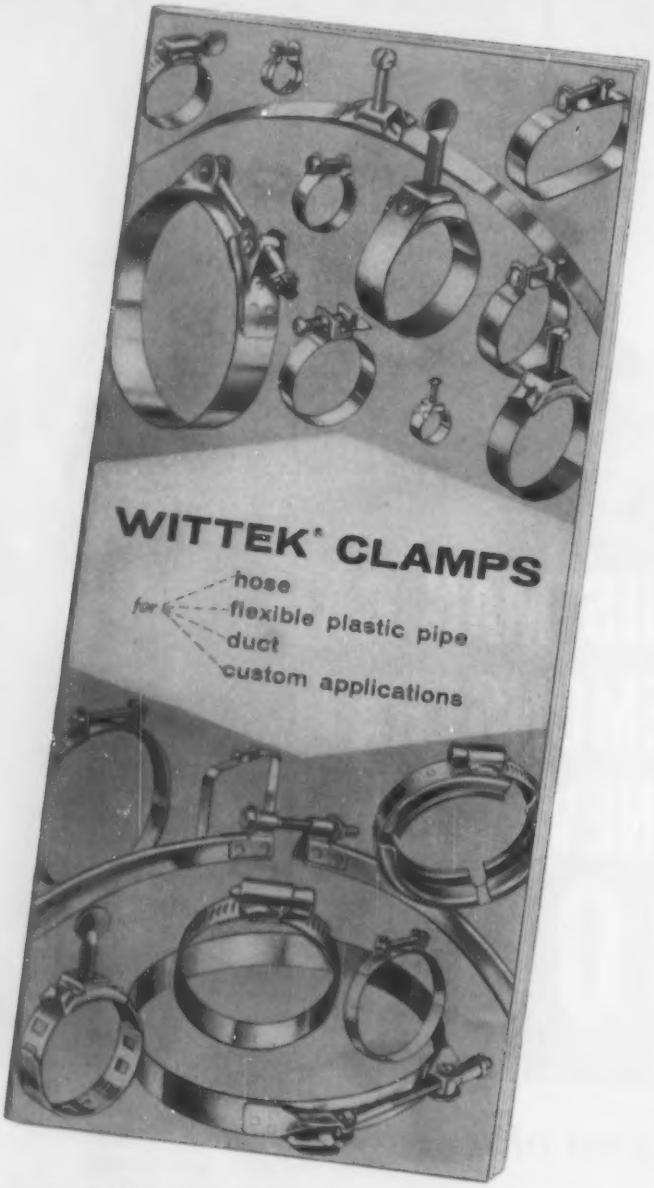
"The Name that Counts"

Hartford, Conn. • New York • Chicago • Los Angeles • San Francisco • Seattle • St. Louis • Greenville, S. C. • Altoona, Pa. • Montreal • Offices and Agents in other principal cities

Circle 506 on Page 19

VRO-58

WHAT'S YOUR CLAMPING PROBLEM?



WITTEK has the answer . . .

Whatever your clamping problem, it's a safe bet that Wittek has the exact type and size clamp to do the job. Write for this new 16-page brochure on standard Wittek clamps and custom-made clamps.

Quality Clamps for Over 35 Years

WITTEK Manufacturing Co.
4349 West 24th Place, Chicago 23, Illinois

CLAMPS for Every Application

dium-duty service. Improved retention of lubricant and exclusion of dirt results from the adoption of an improved lip-type seal. Constructed of a rubber-impregnated fabric between metal shields, seals maintain positive contact with the inner bearing ring at all times, regardless of shaft misalignment. Pillow-block bearings, and the companion flange bearings, utilize an eccentric locking collar to secure the inner bearing ring to the shaft. Setscrew assures positive locking. Bearings are available in a wide range of shaft sizes from ½ to 1 3/16 in. **Hoover Ball & Bearing Co.**, 5400 S. State Rd., Ann Arbor, Mich.

Circle 642 on Page 19

Toggle Switches

have aluminum tabs to provide position indication

Series 400 compact toggle switches feature bright aluminum tabs that provide instant position indication. Switches are available in both momentary and maintained-contact versions. Requiring about 1 in. of space behind control panels and weighing 1/14 oz, switches are suited to aircraft, electronic equip-

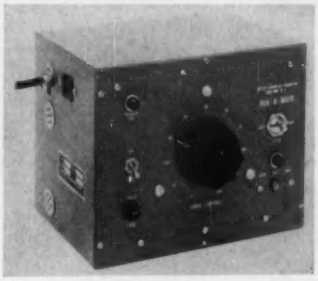
ment, data-processing systems, and industrial consoles. Each toggle operates two precision snap-action switches encased in a dust-tight plastic cover. Each switch has two isolated, SPDT circuits, rated at 5 amp, 125 or 250 v. **Micro Switch Div., Minneapolis-Honeywell Regulator Co.**, Freeport, Ill.

Circle 643 on Page 19

Adjustable-Speed Drives

in ⅓ to ¾-hp range

Model SC-41 adjustable-speed drives are low-cost, high-reliability models covering ⅓ to ¾-hp range. They are available with a variety of speeds and features. Electrical



drives use no tubes, have wide speed ranges with stepless adjustment from zero to full speed, and utilize circuit breakers for armature protection. Remote control is light, small, and compact. Applications include use in process machinery, metalworking machines, printing machines, materials-handling devices, and coil-winding equipment. **Applied Technology Corp.**, 475 Fifth Ave., New York 17, N. Y.

Circle 644 on Page 19

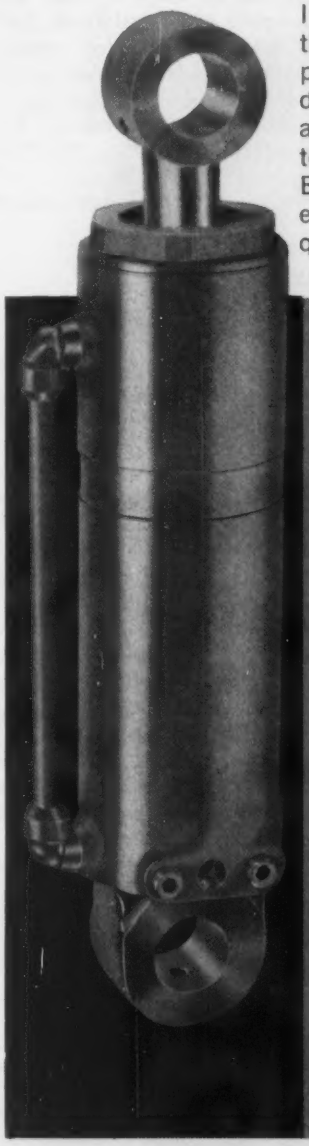
Electrical Transformer

is small, light unit

Flexi-Core electrical transformer is 2 to 30 per cent smaller and lighter than conventional types with identical operating characteristics, depending upon electrical characteristics required. Heart of the transformer is a formed core that consists of nests of laminations of fabricated-steel strips from a continuous roll. Each of these cores consists of two U-shaped nests of strips; two nests are fitted together, with the strips at the top of the U-shapes interleaved or meshed. The result-

BHEW

HYDRAULIC CYLINDERS FOR TOP ON-THE-JOB RESULTS



If you insist upon top performance on-the-job, then always demand B-H-E-W products. Only B-H-E-W offers basic designs and trained specialists to adapt these quality design techniques to suit your specific application. With B-H-E-W working for you, production economies, production efficiency and quality products are your end results!

THIS IS B-H-E-W's "DUAL PILOT" CHECK VALVE. It insures positive piston rod lock in any position when the directional control valve is in neutral. You know the rod will not drift. This simplifies hydraulic line circuitry, eliminates separate pilot operated check valves, connections and lines. Your on-the-job efficiency is highly improved when you use B-H-E-W Hydraulic Cylinders!

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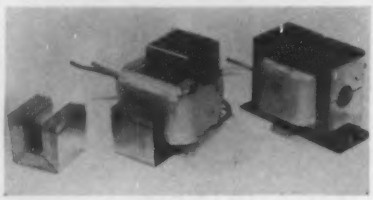
BENTON HARBOR ENGINEERING WORKS, INC.

622 Langley Avenue • St. Joseph, Michigan

Circle 508 on Page 19



ing unit is a hollow rectangle, square, or other shape. Picture shows one of the four nests used to complete the transformer (left). Coil and leads are added (center), and addition of laminations, secured by welds, complete the unit (right). **Sylvania Electric Products Inc.**, General Telephone Bldg., 730 Third Ave., New York 17, N. Y.

Circle 645 on Page 19

Epoxy-Resin Compound

has adjustable flexibility

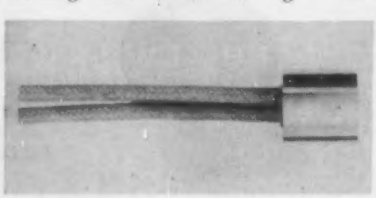
Meta-Cast 441 is a two-part, 100-per cent solids, epoxy-resin casting and sealing compound which contains no reactive diluents or inert plasticizers. Properties of the cured material can be varied from a semi-rigid, hard casting to a rubberlike, flexible sealant by varying the proportions of the two parts. Excellent adhesion and resistance to impact and cracking are maintained over a wide temperature range. Compound is recommended for sealing, potting, and encapsulation of electrical components such as coils, resistors, transformers, rectifiers, and capacitors. **Mereco Products Div., Metachem Resin Corp.**, 530 Wellington Ave., Cranston, R. I.

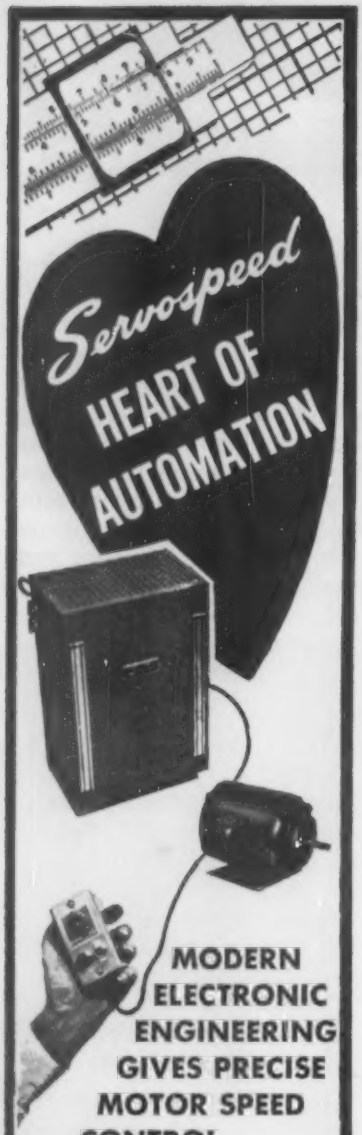
Circle 646 on Page 19

Temperature Detector

miniature unit has sensing element in 0.060 in. of tip

Miniature tip-sensitive temperature detector, only ¼-in. long by 0.278 in. diam, can be connected to indicators, recorders, or controllers by means of ordinary copper wire. Sensing element or winding of the





MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL

1/100 — 10 H. P.

Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

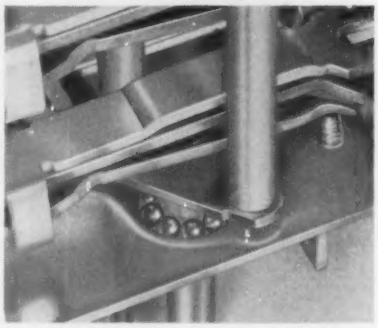
Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J
ARmory 4-8989

Circle 509 on Page 19

ABBOTT

PRECISION-QUALITY BEARING BALLS

are indispensable to the proper function of sensitive, reliable auto radio tuners



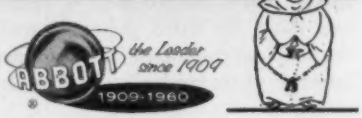
To uphold its redoubtable reputation as a communications specialist, a leading manufacturer of automotive radio systems must be certain that every component used in its assemblies performs reliably.

For example, when this auto tuner assembly is coupled to the electrical system, it must provide positive location and low torque to ensure fine tuning . . . and dependable, precision-quality bearing balls perform a vital function. The bearing balls provide uniform torque between the conical shaft and the bearing race, without introducing tortional strain and undesirable angular displacement . . . and customer requirements for life expectancy and non-degradation in function of the complete assembly are repeatedly satisfied.

Abbott precision-quality bearing balls adapt easily, perform reliably, and last! A wide range of sizes is available. Write for complete information.

Write for copy of Bulletin AP-1

THE ABBOTT BALL COMPANY
118 RAILROAD AVE.
HARTFORD 10, CONN.



Circle 510 on Page 19

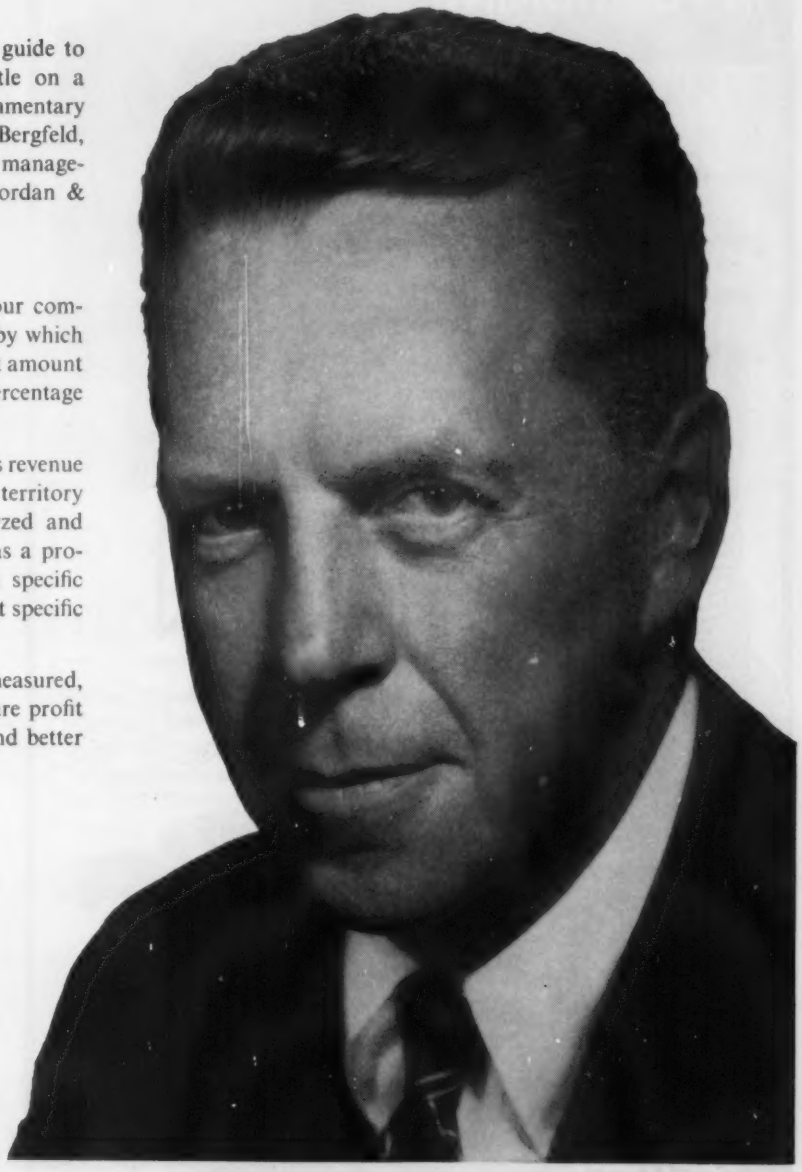
"What's so bad about basing the ad budget on last year's shipments?"

Management men, seeking a reliable guide to advertising appropriations, often settle on a percentage of sales. The following commentary on this practice was written by A. J. Bergfeld, President of the internationally known management consultant firm of Stevenson, Jordan & Harrison, Inc.

"Past practices of your own or of your competitors will produce no magic ratios by which you can either judge or budget the right amount of advertising automatically as a percentage of past sales.

"Plans for increasing sales volume, sales revenue and resulting profits by product and by territory or by divisions, can better be analyzed and approved by considering advertising as a programmed cost to be associated with specific profit plans and to be measured against specific results.

"Programming advertising costs as a measured, reasoned and integrated part of a future profit plan usually results in a better plan and better actual future profits."



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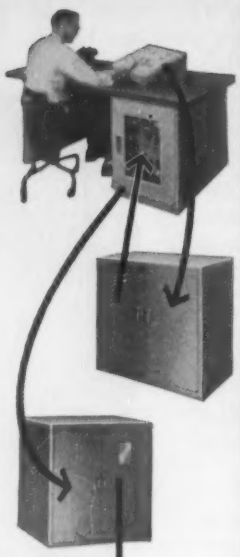
An organization of over 4000 members engaged in the advertising and marketing of industrial products, with local chapters in ALBANY, BALTIMORE, BOSTON, BUFFALO, CHICAGO, CLEVELAND, COLUMBUS, DALLAS, DENVER, DETROIT, HAMILTON, ONT., HARTFORD, HOUSTON, INDIANAPOLIS, LOS ANGELES, MILWAUKEE, MINNEAPOLIS, MONTREAL, QUE., NEWARK, NEW YORK, PHILADELPHIA, PHOENIX, PITTSBURGH, PORTLAND, ROCHESTER, ST. LOUIS, SAN FRANCISCO, TORONTO, ONT., TULSA, YOUNGSTOWN.

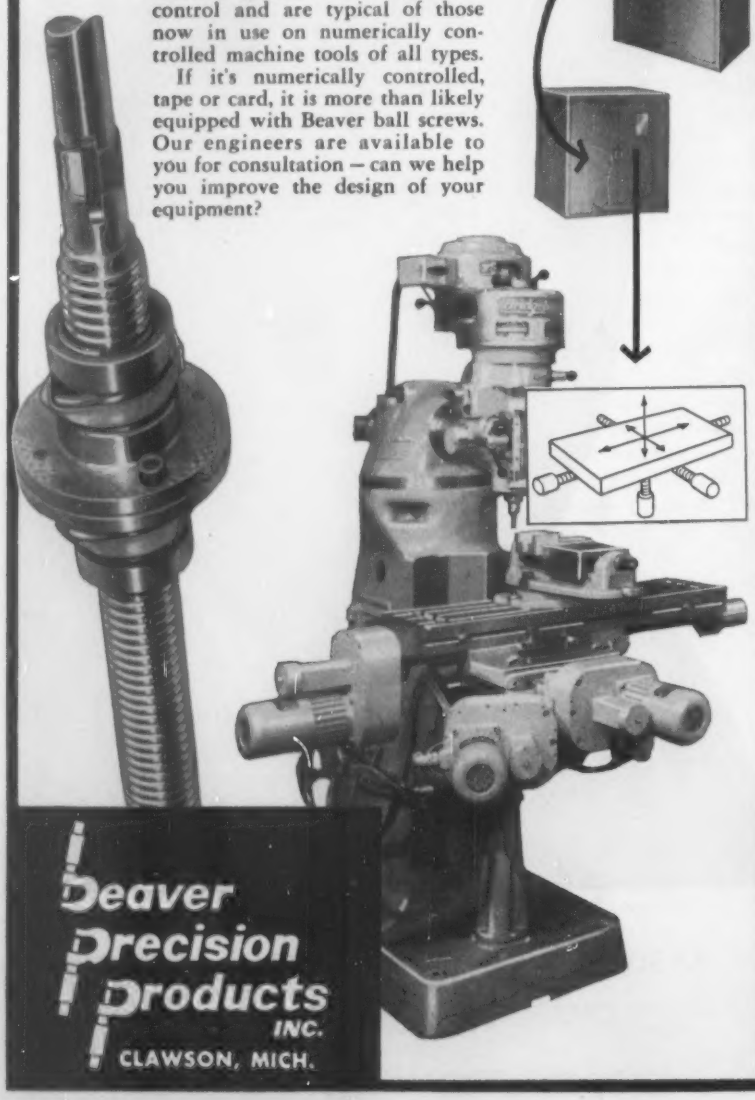
AT THE M.T.B.A. SHOW
NOTE HOW MANY NUMERICALLY CONTROLLED MACHINES RELY ON
BEAVER BALL SCREWS
FOR ACCURACY
IN POSITIONING



Beaver Precision ball lead screws on all three axes provide the basic measuring and actuating elements which simplify the design of this tape controlled milling machine.

Beaver ball screws move table of this Bridgeport Mill in response to signals from the Electronic Control Systems, Inc. "Digimatic" control and are typical of those now in use on numerically controlled machine tools of all types.

If it's numerically controlled, tape or card, it is more than likely equipped with Beaver ball screws. Our engineers are available to you for consultation – can we help you improve the design of your equipment?



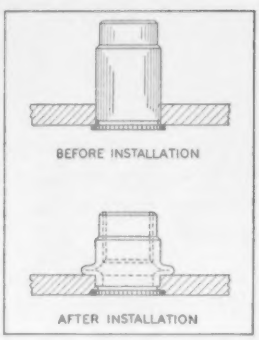
Beaver Precision Products INC.
CLAWSON, MICH.

Model 327 detector is located in the first 0.060 in. of the tip for fast response to temperature changes. Shell of the detector is brass, and tip is tinned so that it can be soldered easily to the metal surface to be measured, or so that it can be covered easily with babbitt if used in a bearing. **Instrument Div., Thomas A. Edison Industries,** McGraw-Edison Co., West Orange, N. J.

Circle 647 on Page 19

Blind-Mounting Lock Nut

for use with 12,000-psi bolts



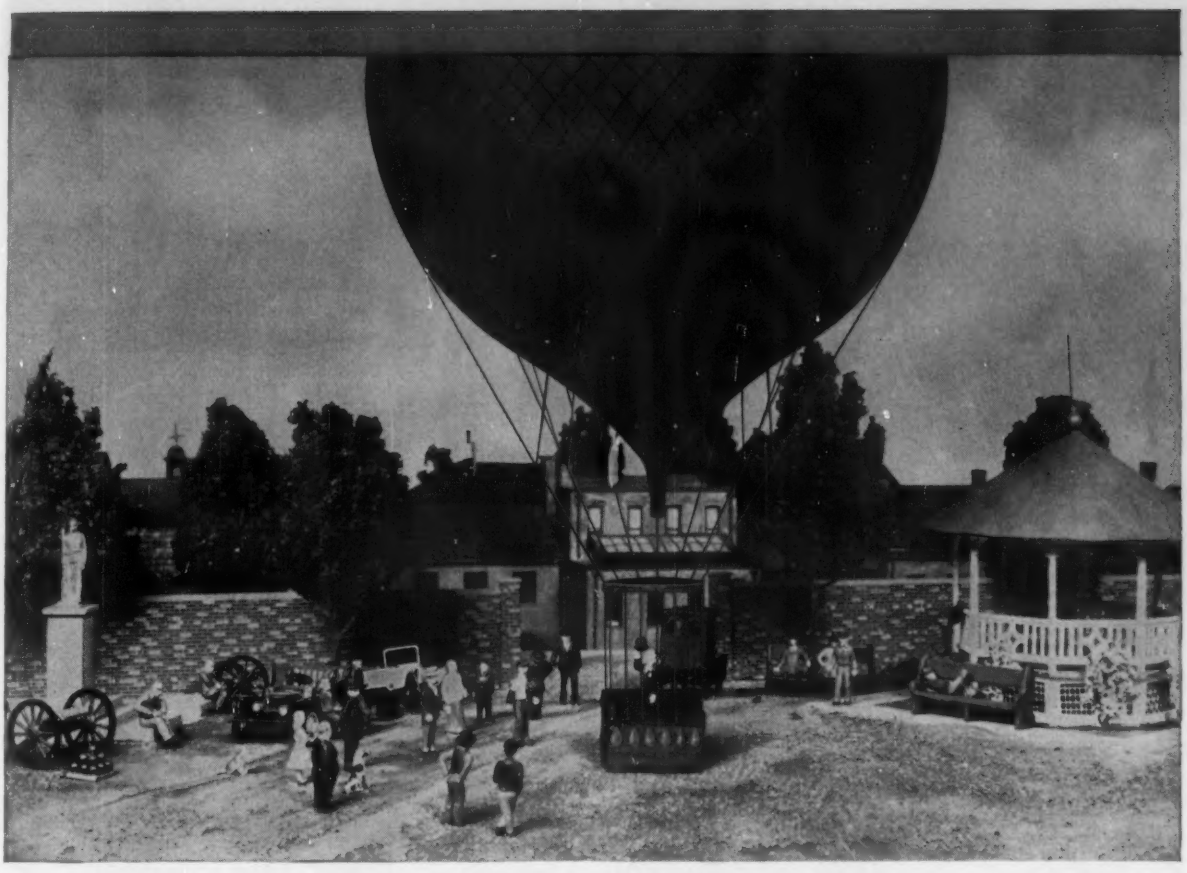
Blind-mounting aircraft and missile lock nut, called the Davis Press Nut, is a one-piece, self-locking, threaded fastener installed from one side in a single drilled hole by a simple pressure tool. Nut is embedded flush in one surface of the metal while gripping the other by a swaging action. Made of austenitic stainless steel, it is intended for use with 12,000-psi tension and shear bolting. It can be used in metal sheets from 0.040 to 0.400-in. thick and of Rockwell C 21. Nut is available in four standard bolt diameter sizes, No. 10 through $\frac{3}{8}$ in., and in nine different grip lengths from 0.040 to 0.400 in., in 0.040-in. increments. Integral prevailing-torque locking feature holds mating bolt firmly in place under vibration, whether seated or not. **Standard Pressed Steel Co.,** Jenkintown, Pa.

Circle 648 on Page 19

Self-Priming Pump

for general-purpose use pumps 300 gph

Small self-priming unit, Pony Pump, is available for 6, 12, 24, or



Are you up in the air over tubing sources?

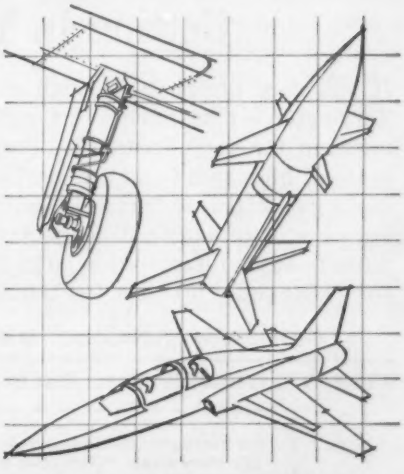
If you have ballooning production problems, consider these important facts. OSTUCO Tubing is always the exact tubing you need for your product because OSTUCO Tubing is CUSTOM MADE for your product. Your order is manufactured to your own specifications to produce steel tubing especially for your application — the precise grade, analysis, size, shape, special anneal and tolerances best suited to your needs.

Ohio Seamless Tube produces both seamless and electric welded steel tubing — is prepared to form many finished or semi-finished tubular parts to your designs.

To get the most from your next steel tubing order, use Custom Made OSTUCO Tubing. Contact your nearest Ohio Seamless representative, or send part drawings to the plant at Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.

A-2449A

Model illustrated built to 3.5 mm scale.



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OHIO SEAMLESS TUBE

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CANADA: Railway & Power Engr. Corp., Ltd. • EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York

Are Small Precision Metal Parts Getting In Your Hair?

If you need precision in small metal parts you can get it from Torrington – plus exactly the right finish, temper and hardness required for your needs. Moreover, Torrington can produce such parts at high speed and a remarkably economical cost. We are the leading specialist in this field -- with the specialized skills, engineering experience and facilities to save you money. If you have small parts to be manufactured in large quantities why not let Torrington solve your entire problem. Use the coupon below to get prompt action.

progress through precision **SPECIAL METAL PARTS**

THE TORRINGTON COMPANY Torrington, Conn.

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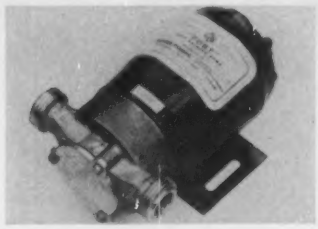


32-v dc operation. Available for marine or general-purpose applications, unit pumps 300 gph. Features include a bronze body, stainless-steel shaft, and neoprene or Hycar impellers. Totally enclosed, 1/12-hp, moistureproof motors are standard. Pump has ¾-in. port connection with ⅜-in. pipe inside thread. **Proven Pumps Div., Western Brass Works**, 1440 N. Spring St., Los Angeles 12, Calif.

Circle 649 on Page 19

Fast-Drying Adhesive

bonds urethane foams or rubber foams to themselves

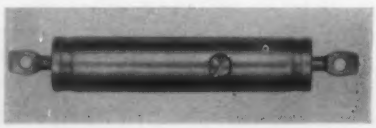
Clear, fast-drying adhesive, Rez-N-glue 301, bonds urethane foams or rubber foams to themselves. Adhesive produces a tough, flexible, nearly translucent bond with rapid rate of open time. Parts can be assembled within five minutes after coating. Maximum assembly strength is developed within ½ to 1 hr after bonding. A tensile pull will tear the urethane without rupturing the bond. Application of the adhesive is made by brushing of the surfaces to be bonded. After three to five minutes open time the sections are pressed together to assure good contact. **Schwartz Chemical Co. Inc.**, 50-01 Second St., Long Island City 1, N. Y.

Circle 650 on Page 19

Insulated Thermostat

has maximum contact rating

BW-SS insulated thermostat is a ¼-in. diam model available with wiping action and contacts that open and close with temperature fluctuations. Unit can be factory-

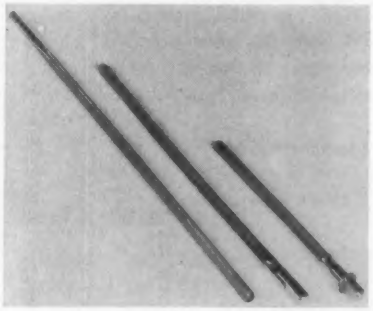


calibrated or adjusted externally to obtain desired actuating temperature by means of an easily accessible adjustment screw. Temperature setting is not affected by ambient temperatures. Model incorporates a bimetal-actuated contact attached to a spring which shunts the bimetal. Unit is particularly recommended for applications requiring an insulated thermostat with maximum contact rating. Maximum differential is 1 deg. **Chatham Controls Corp.**, 156 River Rd., Chatham, N. J.

Circle 651 on Page 19

Flexible-Shaft Couplings

have squared ends



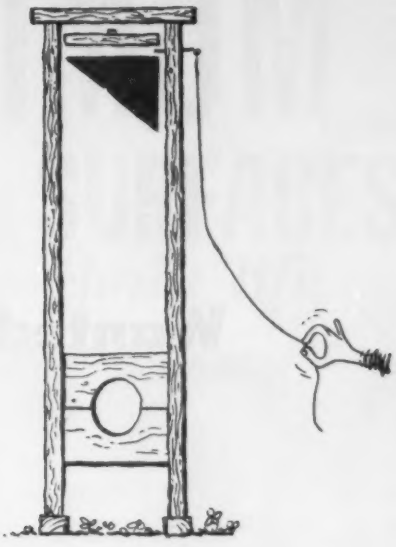
Flexible-shaft couplings are made of 5/16-in. diam flexible-shaft core. Core is made of high-carbon wire and operates in temperatures to 300 F. Square formed on end of coupling facilitates the engagement for the drive and also allows for slight changes in length due to varying torques. Formed square on the end is held to close tolerance and is lcwer in cost than fittings. Length can be varied to suit the particular application. Couplings are suited for controls that must operate at temperatures too high for hydraulic controls, such as in high-temperature jet aircraft. **Stow Mfg. Co.**, 11 Shear St., Binghamton, N. Y.

Circle 652 on Page 19

Synchronous Motor

permits ac synchronous speed or dc stepping

Permanent-magnet type synchronous motor, Slo-Syn SS250, is designed primarily for heavy-duty industrial use. Torque of 250 oz-in. and constant speed of 72 rpm make

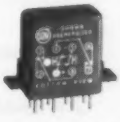


SIGMA

CAN NOW TAKE CARE OF COMPETITION IN ON-OFF DEVICES

The Great Competitive Game being what it is, drastic measures are often necessary if a new product is to be assured of success. Frequently, one must even resort to publishing better specs than the competitor has announced, and then build a product to meet them. Some companies even go so far as to reverse the order of these events but the procedure is rare in North America.

We used to say the Sigma Series 33 was a sliding current relay and that it would work on 200 milliwatts. Now there is evidence to the contrary: (1) the "33" works best when *abruptly* energized, and (2) there's a new adjustment coded "VG" that needs only *100 mw* for operation. (How's that for being wrong two out of two?)



Series 33 relay

This new subminiature competitor (on the left, next to Dr. Guillotin)

stays within spec and won't open its contacts, energized or not, at 30 g to 5000 cycles, under 70 g shocks, and over a −65°C. to +125°C. temperature range. Contact form is DPDT, polarized, magnetically biased. This is designated "Form Y" by us and means that the armature occupies one closed position when there is no coil signal, the other closed position when a signal of correct polarity and magnitude is applied, and back to the first position when the signal is removed. On special order, 33VG's can be supplied with dual coils and/or gold alloy contacts for dry circuit work.

One other thing about applications: the VG adjustment of the 33 is good for either on-off or off-on requirements; order device in main illustration only if your application is the former. Series 33 Bulletin and VG supplement on request.

At WESCON—Booth 749-750

SIGMA

SIGMA INSTRUMENTS, INC.

89 Pearl St., So. Braintree 85, Mass.

An Affiliate of The Fisher-Pierce Co. (since 1939)

Circle 515 on Page 19

Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications.

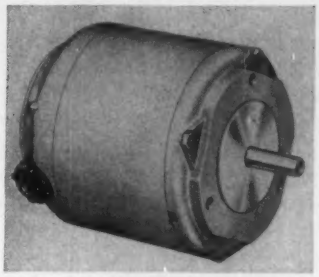
If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN



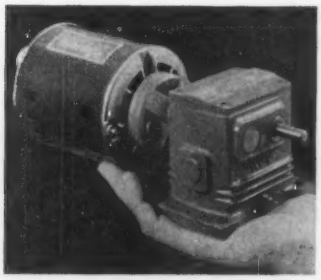
it well adapted for service as a prime mover for controlling valves, temperature, machine-tool carriages, and similar automatic or semiautomatic applications. Unit can be started, stopped, or reversed instantly with a single-pole, three-position switch. Ratings are: Input 120 v, 40/70 cycles, single phase, 0.6 amp maximum current (at 60 cycles); 72 rpm output speed at 60 cycles; 250 oz-in. torque. **Superior Electric Co.**, Dept. SS, 83 Laurel St., Bristol, Conn.

Circle 653 on Page 19

Speed Reducer

provides output speeds from 1.9 to 70 rpm

MW109 Ratiomotor, worm-geared, horizontal, parallel-drive model, is powered by specially designed 1/20 or 0.035-hp motors. It provides out-



put speeds from 1.9 to 70 rpm and is available as a standard stock model. **Boston Gear Works**, Quincy 71, Mass.

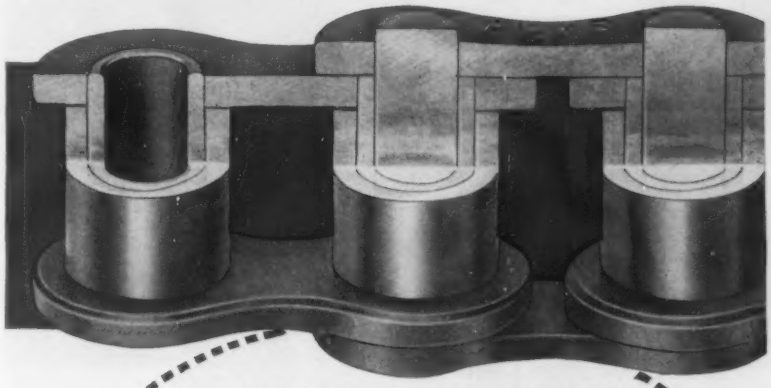
Circle 654 on Page 19

Silicon Power Rectifiers

have high reliability in environmental extremes

Combining a high forward-current rating of 400 ma with extremely small size, low-cost subminiature silicon rectifiers utilize Tri-Seal construction which assures high reli-

MAXIMUM WEARING SURFACES *for longer chain life*



ACME'S SECRET *for years of additional service*

Special hardening of pins, bushings and rollers help insure maximum life expectancy of ACME Roller Chains. All parts subjective to articulation have glass-hard wear-resistant surfaces to render eminent life expectancy. The side plates or links which act as connecting members for articulating parts are specially heat treated and tempered to insure great strength and ductility.

Maximum hardening of all wearing surfaces on ACME Chains is conducive to longer life, resulting in greater economy and lower maintenance cost.

Your local distributor has a complete line of ACME Chains and Accessories on hand for immediate delivery. Call him.

Write Dept. 6-F for new 100-page illustrated technical catalog including new engineering section showing 36 methods of chain adjustments.

Acme Chain Corporation
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Circle 517 on Page 19

3 Ways to Slash Fastening Costs with

PALNUT® LOCK NUTS and FASTENERS

1. Save on First Cost

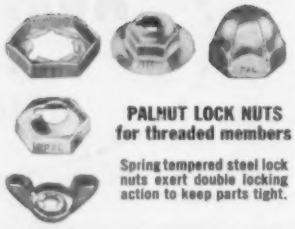
PALNUT Lock Nuts and Fasteners are precision-produced in enormous volume at exceptionally low cost. They are priced lower than other locking methods, often less than plain nuts.

2. Save on Assembly Cost

PALNUT Lock Nuts and Fasteners apply easily and fast with ordinary tools. Assembly is greatly simplified and speeded-up by using PALNUT magnetized sockets and applicators which permit picking up, starting and tightening in one high-speed operation.

3. Save auxiliary parts and operations

A single PALNUT Lock Nut or Fastener replaces two, three, even four fastening parts according to application. You can eliminate lockwashers, flat washers, sealer washers and cotter pins. You can save the extra cost of threading, drilling or grooving other fastening members. Assemblers handle a single PALNUT —reducing parts to buy, stock and assemble.



PALNUT LOCK NUTS for threaded members

Spring tempered steel lock nuts exert double locking action to keep parts tight.

PUSHNUT® FASTENERS for unthreaded studs and rod

Simply push on for fast assembly. Strong spring grip holds parts tight.

PALNUT SELF-THREADING NUTS

Make their own threads while tightening on unthreaded studs, rod and pins of any malleable material. Save cost of threading—apply fast—hold tight.

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Also consult Sweet's Design File.

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75 Glen Road, Mountainside, N. J.

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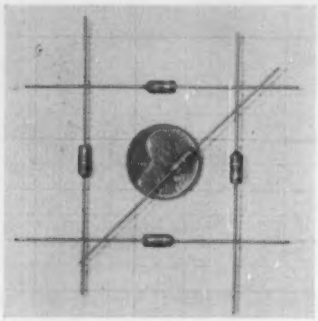
LOCK NUTS and FASTENERS



ability in environmental extremes. Electrical specifications include reverse leakages of only 1 mu amp at rated peak reverse voltage at 25 C, maximum voltage drop of 1 v at rated current, and surge-current capabilities of 3 amp over operating temperature range from −65 to +130 C. Designated Types X4M2 through X4M6, units provide a peak-reverse-voltage range from 225 to 600 v, and are capable of high-temperature operation. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif.

Circle 655 on Page 19

Cabinet Handles

for many types of metal enclosures

Two new designs in multiuse cabinet handles consist of a lever style (left), and a tee style. Handles are designed for cabinet doors, machinery housings, electronic data-proc-

essing units, and many other types of metal enclosures. **Corbine Cabinet Lock Div., American Hardware Corp.**, New Britain, Conn.

Circle 656 on Page 19

Silicone Rubber

contains heavy metal particles

Cohrlastic HG silicone rubber combines a high percentage of heavy metal particles, finely divided and

uniformly dispersed, in silicone rubber. Properties of the metal-filled silicone rubber include broad temperature range (−85 to +500 F); extremely good resistance to weather, ozone, and ultraviolet light; unusually uniform shielding against x-rays or other high-energy radiation; good electrical resistance properties; high specific gravity; a resilient and flexible rubbery material. Material can be processed in the same manner as normal rubber compounds, including molding, extrusion, calendering, and as a coating on fabric. **Connecticut Hard Rubber Co.**, Dept. 5137, 407 East St., New Haven, Conn.

Circle 657 on Page 19

Silicone Additive

is thinner for RTV silicone rubber

Silastic RTV Thinner is a fluidlike silicone additive which adjusts and controls the viscosity of RTV-type silicone rubbers. Material makes it possible to increase the flowability of uncured RTV silicone rubbers without affecting their performance. Using the new thinner, it is possible to reduce the viscosity of Silastic RTV rubber by as much as 75 per cent of its original consistency without significant changes in the physical properties of the fully vulcanized rubber. Thinner permits user to maintain a Silastic RTV system that is free of volatile solvents. **Dow Corning Corp.**, Midland, Mich.

Circle 658 on Page 19

Teflon Dry Seal

can be used on a variety of materials

Teflon tape for dry sealing all types of threaded pipe joints and threaded cable connectors can be used on a wide variety of materials including steel, iron, brass, plastic aluminum, Monel, and synthetic rubber. Tape is unaffected by temperatures from −250 to +500 F, and is chemically inert. Designated Wrap-It, it is supplied in ½-in. widths in ten standard colors. **Hitemp Wires Inc.**, 1200 Shames Drive, Westbury, N. Y.

Circle 659 on Page 19

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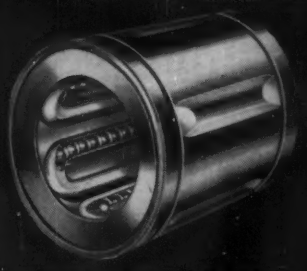
Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your **LINEAR MOTIONS**



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Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

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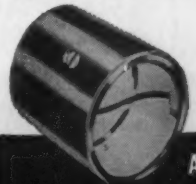
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

The various types cover a shaft diameter range of ⅛" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.



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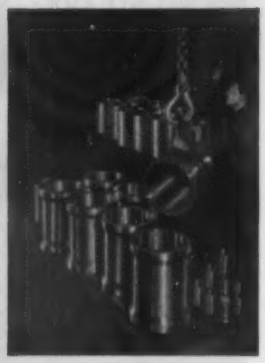
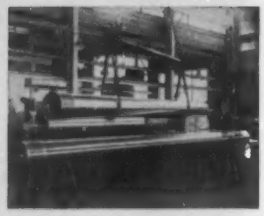
Dept. E, MANHASSET, NEW YORK

Circle 519 on Page 19

Also Manufacturers of NYLINED Bearings . . . Sleeve Bearings of DuPont Nylon, and 60 CASE . . . Hardened and Ground Steel Shafting





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Shenango's centrifugal casting process insures longer life because of finer, more uniform, *pressure-dense* grain to begin with . . . free of inclusions, porosity, blowholes and other weakening defects. Then, far less machining is needed and your part is stronger . . . to last and last *and last!*

Shenango's modern and fully-equipped shops will supply you with ferrous or non-ferrous symmetrical parts in virtually any shape or size . . . rough, semi-machined or precision-finished to your most exacting specifications. For full details, write: *Centrifugally Cast Products Division,* The Shenango Furnace Company, Dover, Ohio.

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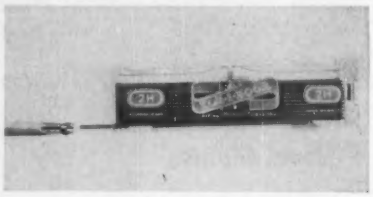
ENGINEERING DEPARTMENT

EQUIPMENT

Lead Dispenser

has spring-action feed

Improved Ejectomatic lead dispenser feeds lead automatically to the holder without the need of handling



the lead. Improved version substitutes a spring-action feed in place of the gravity feed formerly used. It makes lead replacement and exchange quicker and more convenient. All 17 degrees of drawing leads are packed in the dispenser. **Koh-I-Noor Pencil Co.,** Bloomsbury, N. J.

Circle 660 on Page 19

Drafting Tables

have maximum board size of 43½ x 84 in.

Four-post hardwood drafting tables with steel drawers that never stick, warp, or swell, and hardwood pedestal drawing tables with positive-lock tilt to prevent board slippage comprise Woodmaster line, furnished in 11 models. Solid basswood drawing board tops are kiln-dried, smoothly finished, sealed, and lacquered. Zinc-plated steel end cleats protect board ends and allow for expansion and contraction. Nylon glides assure smooth, quiet operation of steel drawers of four-post

drafting tables. Five models have board sizes from 37½ x 48 to 43½ x 84 in. Positive lock tilt on pedestal tables keeps board tops steady under pressure and eliminates need for constant adjustment. Six pedestal models have board sizes from 31 x 42 to 43½ x 84 in. **Stacor Equipment Co.**, 295 Emmet St., Newark 5, N. J.

Circle 661 on Page 19

Copying Machine

has speed to 40 fpm

Improved tabletop model of Ozamatic whiteprint copying machine, called Ozamatic 60, offers five new features. Included are: Faster speed, up to 40 fpm; better stacking of originals and prints due to a new roller drive; larger feedboard for better paper handling at the machine; easier feeding of prints due to feed belts positioned closer to the operator; easier cylinder cleaning inside, outside, and while the

machine is in motion. Ozamatic 60 copies single-side originals up to 15 in. wide by any length. It produces anything typed, printed, written, or drawn on translucent paper, film, or tracing cloth. Printing and development are synchronized into one continuous operation. Developer screen of perforated Teflon provides a frictionfree surface that eliminates print scratching or soiling. Unit is a dry-process white printer which eliminates the necessity of mixing chemicals or regular washing out of the developer chamber. All machine controls are located on the front panel within easy operator reach. Unit operates on 115 v ac, 60 cycles, single phase. **Ozalid Div., General Aniline & Film Corp.**, 49 Corliss Lane, Johnson City, N. Y.

Circle 662 on Page 19

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Circle 521 on Page 19

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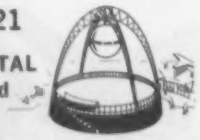

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Circle 522 on Page 19

THE ENGINEER'S Library

Recent Books

Fundamentals of Rocket Propulsion. *By Raymond E. Wiech Jr. and Robert F. Strauss; 135 pages, 6¼ by 9¼ in., clothbound; published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; available from* MACHINE DESIGN, *$5.50 per copy postpaid.*

Operating fundamentals, design of components, and methods of applications of rocket engines are thoroughly covered. Design information includes basic laws covering rocket engine design, design and operation of current engines, and the need for and probable design of future engines.

All basic rocket formulas are derived from algebra rather than calculus. Many new terms are explained, and uncommon rocket devices are illustrated and discussed.

Colour in Industry Today. *By Robert F. Wilson; 90 pages, 7 by 10 in., clothbound; published by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$8.00 per copy postpaid.*

A practical treatment of the functional use of color is presented. Psychological effects of color combinations in the design of machines, factories, schools, and commercial establishments are discussed. A chapter is devoted to the important relationship between color and light.

Association Publications

Proceedings of the Engineering Materials and Design Conference—Earls Court London. *232 pages, 8 by 13 in., paperbound; published by and available from Heywood & Co. Ltd., Drury House, Russell St., London, W. C. 2.*

Recent developments in the field of engineering materials and design were discussed in twenty papers. Topics included standards, reinforced plastics, industrial design, safety, photoelasticity, powder metallurgy, rotating shaft seals, high-pressure hydraulic equipment, vac-

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uum-melted materials, and design of rubber components.

Elevated-Temperature Properties of Chromium Steels—STP 228. *By Ward F. Simmons and Howard C. Cross; 124 pages, 8½ by 11 in., paperbound, stapled; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $4.25 per copy.*

Strength properties of 23 chrominum steels at temperatures up to 2400 F are presented. Data include tensile strength, yield strength, elongation, and rupture and creep properties. Chromium content ranged from 12 to 27 per cent.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 161262. Fundamental Investigations of Electrical Power Sources: Volume II—Batteries. By E. J. Hellund, Plasmadyne Corp.; 97 pages, 8 by 10¼ in., paperbound, stapled; $2.25 per copy.

Performance characteristics, structure, power-weight ratios, and power-volume ratios of chemical and 'nuclear' batteries are surveyed. Performance data on various battery types include whr per lb, whr per cu in., reliability, behavior at low temperatures, and adaptability for particular kinds of service.

PB 161206. Transistorized Power Supplies—A Literature Survey. By Floyd Allen, Diamond Ordnance Fuze Laboratories; 23 pages, 8 by 10½ in., paperbound, stapled; $0.75 per copy.

This survey shows how to use various electrical converters to best advantage to get high voltages from a low-voltage dc power supply. Efficiencies of transistorized converters, vibrator-transformer converters, and dynamotors are compared. Examples are given of functional circuits using power transistors as controlled switches.

PB 161274. High Energy Rate Metal Forming—Report No. 5. By A. F. Watts and G. N. Rardin, Lockheed Aircraft Corp.; 267 pages, 8 by 10½ in., paperbound, stapled; $4.00 per copy.

Results of high-explosive forming tests on two steel and two titanium alloys are described. Strain rates, velocities, and temperatures were measured. Metallurgical effects of materials subjected to high strain rates were observed.

PB 161297. Statistical Evaluation of Data from Fatigue and Creep-Rupture Tests: Part 1—Fundamental Concepts and General Methods. By Waloddi Weibull, Bockamollan, Brosarps Station, Sweden; 80 pages, 8¼ by 10¾ in., paperbound, stapled; $2.00 per copy.

Metal fatigue tests are classified according to short-life, medium-life, and long-life stress levels. Possibilities for estimating distribution parameters are examined.

PB 161302. Materials-Property-Design Criteria for Metals: Part 8—The Creep Behavior of Selected Materials in the Range up to 1 Per Cent Net Creep Strain and 1000 Hours. By R. J. Favor, W. P. Achbach, and H. J. Grover, all from Battelle Memorial Institute; 30 pages, 8¼ by 10¾ in., paperbound, stapled; $0.75 per copy.

Creep data on aircraft structural materials were compiled and evaluated. Time-deformation curves and creep data are presented in charts calibrated by time in minutes and deformation rate in per cent.

PB 161354. Temperature Conversion Tables. By Wayne A. Brodhecker and Numerical Mathematics Staff, U. S. Naval Avionics Facility; 80 pages, 8 by 10½ in., paperbound, side-stapled; $2.25 per copy.

Tables for converting degrees F to degrees C are presented with three-place accuracy for temperatures from −100 F to +300 F. Tables were calculated on an IBM 650 computer.

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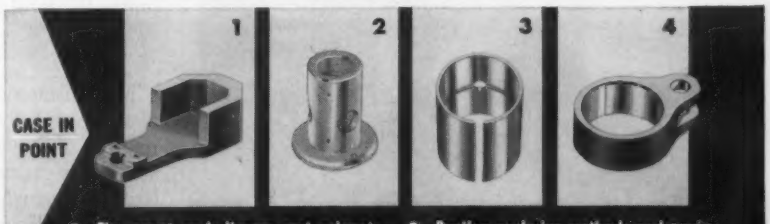

1 The great and diverse cost advantages of powder metallurgy are revealed in the highly complex nature of this bearing support plate for power tools made in Bunting's Powdered Sintered Metals Plant.

2 An Aluminum Alloy helped cut the cost of this high speed turbo super charger bearing with its intricate machining of many dimensions and close tolerances.

3 Bunting exclusive methods and equipment reduced to the minimum the cost of this cast bronze spindle bearing with its extremely rigid specifications.

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Circle 523 on Page 19

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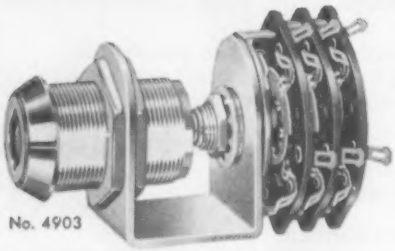
CHICAGO ACE®
PIN TUMBLER LOCKS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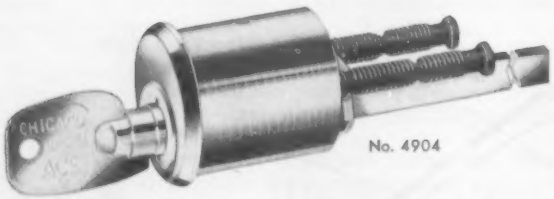
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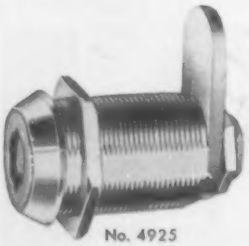
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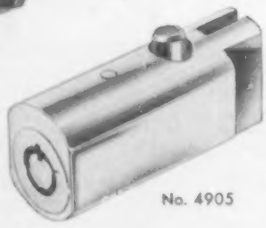
Hardened Steel ACE Key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Here is the only line of locks listed by Underwriters' Laboratories. The unique ACE Locks provide the maximum in mechanical security. Over 80,000 keying combinations are possible so that you may have your own factory-registered tumbler set-up. For technical details on models available for various applications, write for Switch Lock Bulletin UB 501.

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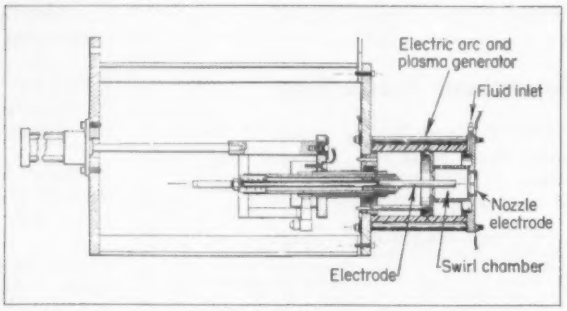
NOTEWORTHY

Patents

Fluid-Stabilized Arc Mechanism

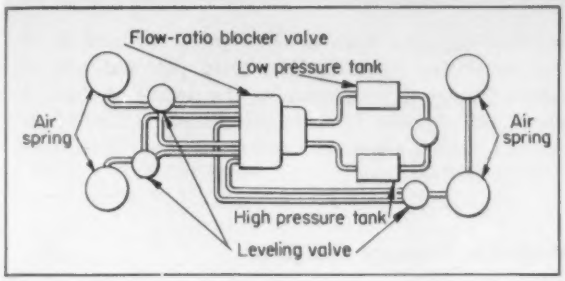
Delivery of high-temperature plasma for extended periods is achieved by a fluid cooling system and selective control of the arc. A fluid, as water, surrounds the swirl chamber under pressure. Ports allow the fluid to enter the swirl chamber in the manner of a vortex. When the arc between the electrode and the electrode nozzle is struck, the fluid in the swirl chamber condenses or constricts the arc. Part of the fluid boils away and is ejected with the plasma through the nozzle electrode. *Patent* 2,943,182 *assigned to General Electric Co. by John W. Prout, Noel J. Sheehan, and James W. Reid Jr.*



Motion-measuring system uses a pair of radiation pickups and a piece of radioactive material to detect motion of inaccessible parts, such as a wheel within a turbine casing. The piece of radioactive material is fixed to the wheel. The two pickups are placed so as to be in alignment with the radioactive material at one position in a revolution. They are also interconnected with a rate meter which registers revolutions only when both pickups receive radiation impulses simultaneously. Additional pairs of pickups, similarly aligned and connected, permit the charting of the motions of more than one body in the same enclosure. *Patent* 2,939,013 *assigned to General Motors Corp., Detroit, by Alexander Somerville.*

Air-Suspension Flow-Ratio Valve

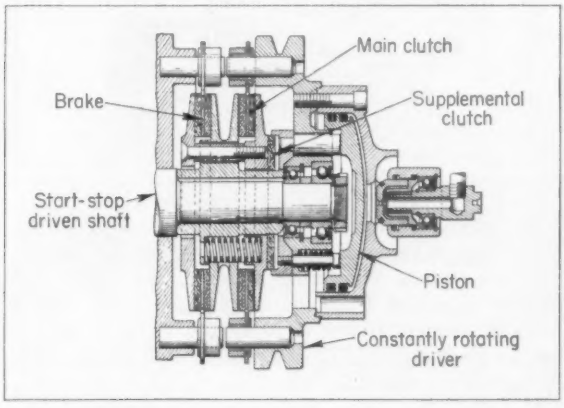
Dual diaphragms and blocker-valve assemblies, within a flow-ratio valve, provide rapid flow of air to and from the leveling valves for air springs. When the load on the springs increases, the blocker valve uncovers high-pressure ports to admit rapid flow of air to the leveling valves. When the load decreases, an opposing blocker valve uncovers low-pressure ports to allow air to flow rapidly from the leveling valves. When the load is constant, or nearly so, both blocker valves remain



closed; flow to adjust differences in pressures occurs through connecting orifices. A greater difference in pressure is required to unseat either blocker valve than that needed to keep it seated. *Patent* 2,939,725 *assigned to General Motors Corp., Detroit, by Robert W. Graham.*

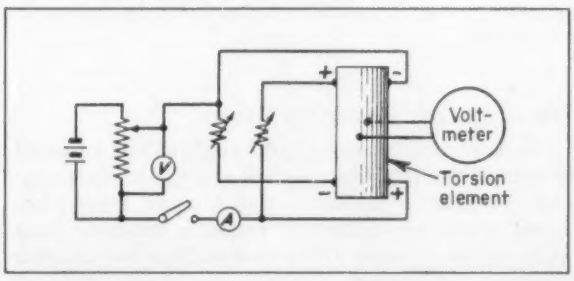
Air-Operated Clutch-Brake Mechanism

Clutching, de-clutching, and braking a power-driven shaft requiring start-stop operation are accomplished by three disc-type friction assemblies. Movement of the piston to the left under air pressure sequentially en-



gages the supplemental friction clutch, releases the brake, and engages the main clutch. The pickup in torque is gradual. Upon release of the air pressure the clutches are disengaged and the brake is set by springs. *Patent* 2,942,708 *assigned to Industrial Clutch Corp., Waukesha, Wis. by Clarence M. Eason.*

Force-Responsive Electrical Device



A semiconductive material such as germanium forms the torsion element of an electrical device for strain measurements. The torsion element has three pairs of

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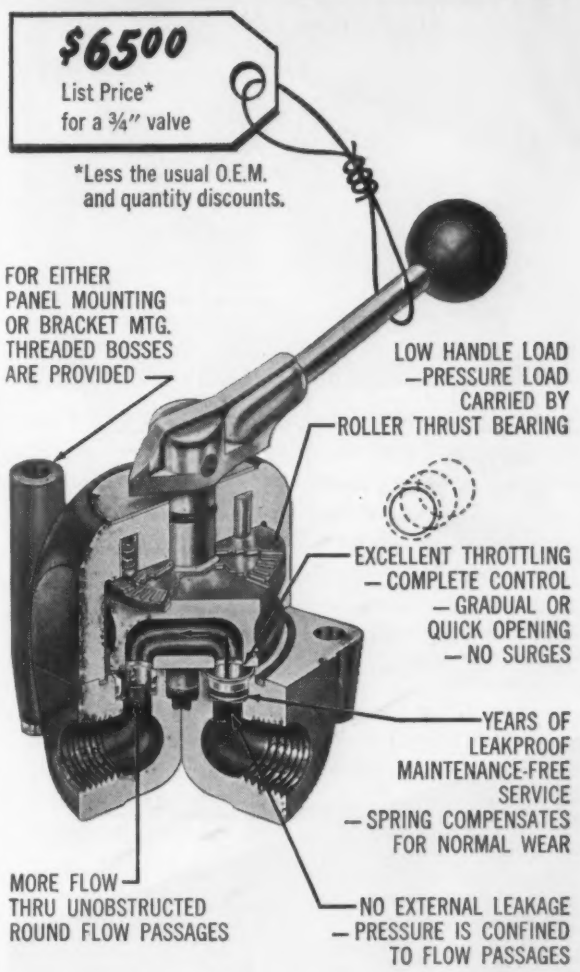
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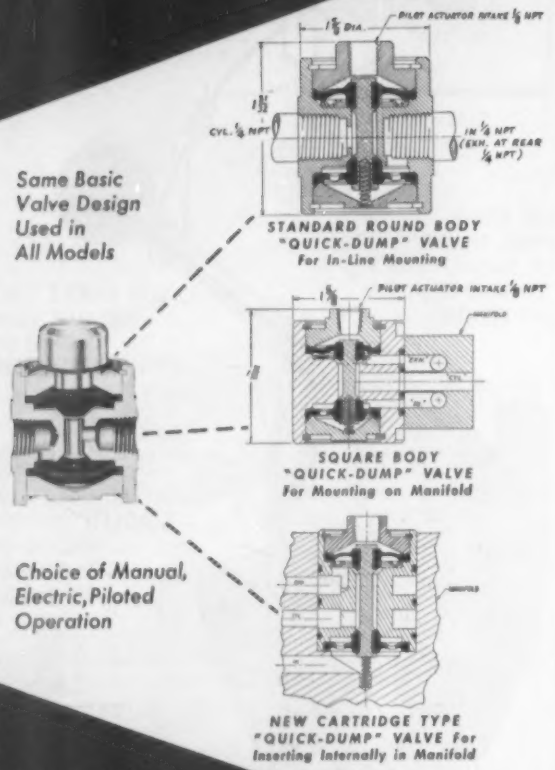
Circle 525 on Page 19

Versatile Humphrey
"Quick-Dump"
Valves Provide
NEW FLEXIBILITY
In Designing
Pneumatic Controls


PILOT ACTUATOR INTAKE 1/8 NPT
CYL. 1/8 NPT
IN 1/8 NPT (EXH. AT REAR 1/8 NPT)
STANDARD ROUND BODY "QUICK-DUMP" VALVE For In-Line Mounting
Same Basic Valve Design Used in All Models
SQUARE BODY "QUICK-DUMP" VALVE For Mounting on Manifold
Choice of Manual, Electric, Piloted Operation
NEW CARTRIDGE TYPE "QUICK-DUMP" VALVE For Inserting Internally in Manifold

The basic "Quick-Dump" Valve, small in size, large in capacity, lightning-fast in operation, permits endless variations in body type, methods of mounting, methods of actuating.

There are round, square, cartridge styles; 2-way, 3-way, 4-way; 1/8", 1/4", 1/2" sizes; manual, electric, or pilot-operated. All valve air, oil, water, other liquids, gases to 125 psi. Also vacuum.

Utilizing the flexibility of "Quick-Dump" Valves, Humphrey engineers are producing a continuous flow of new pneumatic controls, both for plant processing and OEM applications.

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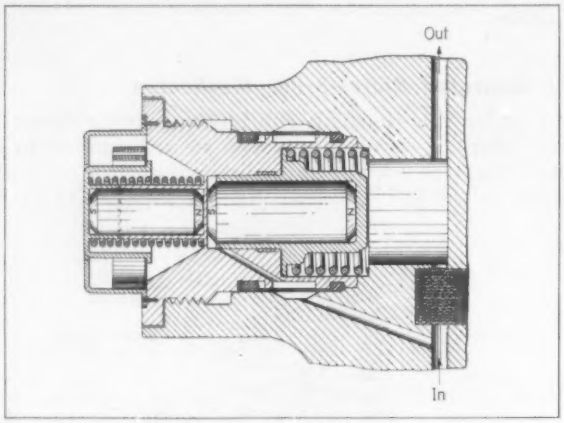
electrical contacts. Two of these pairs are used to introduce biasing currents. The third pair indicates an output voltage in proportion to the degree of strain to which the element is subjected. *Patent 2,939,317 assigned to Bell Telephone Laboratories Inc., New York, by Warren P. Mason.*

Magnetic Pressure Indicator

Pressure differences greater than a predetermined value are detected by magnetic attraction. Two magnetic elements are held against a common diaphragm by a coil spring (the larger), the outlet pressure and magnetic attraction. Inlet fluid pressure acts on the

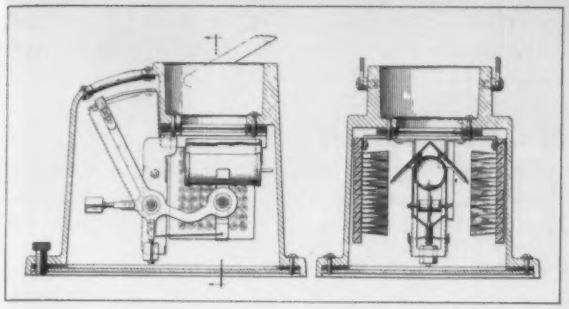


larger magnetic element in the manner of a piston. When the difference between the inlet and outlet pressures exceeds the spring pressure, the piston element is separated from the diaphragm. The second magnetic element is free to move and serves as the indicator. *Patent 2,942,572 assigned to Pall Corp., Glen Cove, N. Y. by David B. Pall.*

Miniature switch mechanism is operated by a magnetic field. The switch contacts are sealed inside a cylinder, which can be as small as 3/16 in. diam by 5/16 in. long. Magnetic attraction brings the contacts together when the switch is properly oriented between the poles of a magnet. Voltage and current are low, being in the order of 1/10 volt or less and a few microamperes, respectively. *Patent 2,932,703 assigned to Hughes Aircraft Co., Culver City, Calif. by Ernest R. Haberland.*

Sonic-Pressure Measuring Device

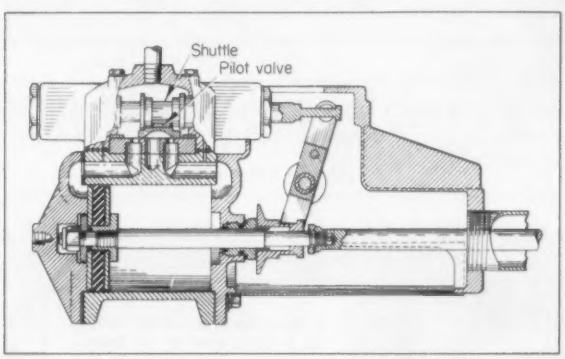
Parallelogram linkage, counterweighted and balanced to swing like a pendulum, carries a target for the reception of radiation pressure from a sound transmitter. Sound waves are generated within a chamber filled with degasified water. They emerge from the chamber through a diaphragm to strike the target, which is deflected through an arc in proportion to sound pressure. The thickness of the diaphragm is gaged in half-wave lengths of the speed of sound within the dia-



phragm material. *Patent* 2,939,542 *assigned to the Birtcher Corp., Los Angeles, by Robert A. Weller and Horace T. Finch.*

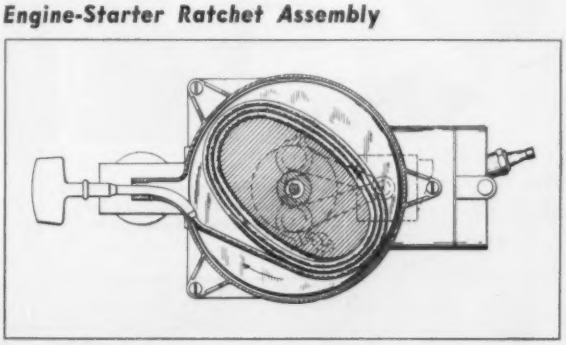
Reciprocating Fluid-Motor Valve

Two-way control of the reversing valve in a reciprocating fluid motor is provided by a pilot-valve system and a rocker-arm shifting mechanism. At low speeds, the pilot valve provides snap-action reversal of pressure from one face of the piston to the other at



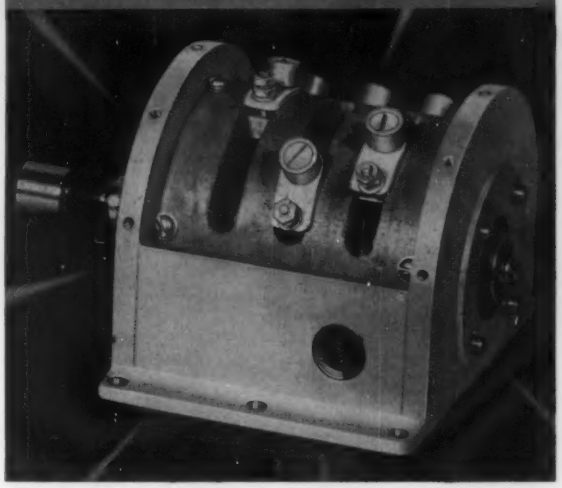
the end of piston travel. At high speeds, the rocker-arm mechanism effects reversal before the pilot-valve system can build up sufficient pressure to act. The same shuttle positions both mechanisms for operation at the end of piston travel in either direction. *Patent* 2,939,433, *assigned to Stewart-Warner Corp., Chicago, by Earl Feicht.*

Engine-Starter Ratchet Assembly



Mechanical advantage during manual starting of small engines is provided with a pulley of variable radius. In between the pulley and the engine is a ratchet de-

NEW ROTARY SWITCH
for HEAVY DUTY USE
Adaptable to cycling equipment where safety, dependability and long life are a requisite



Its broad applicability is an important feature of Superior's *new* rotary switch. Its flexible basic design enables it to be used advantageously on existing cycling equipment; also makes it adaptable to many O.E.M. applications. The switch shuts off power at the end of each cycle and automatically starts the cycle unless interrupted. Safety is a bonus feature with a new high attained in dependable, long ring life. . . Send us your current requirements and other data for our quotation.

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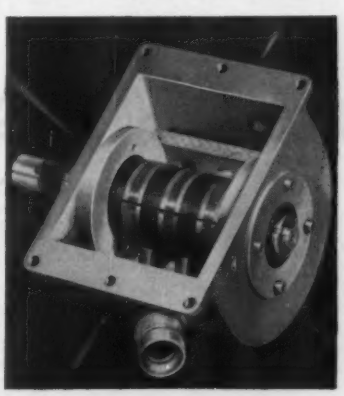

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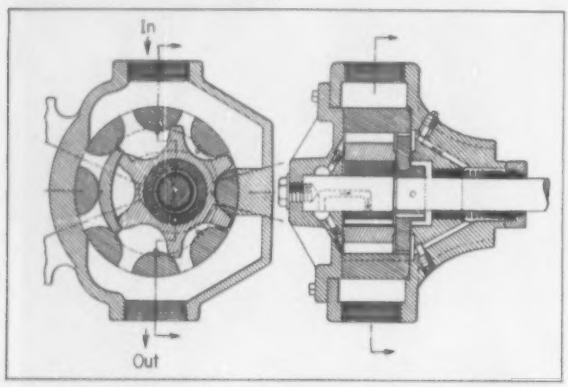
Circle 527 on Page 19

vice that properly positions the pulley to the engine for starting. As the engine piston or pistons approach the positions of maximum compression, the radius of the starting pulley increases to equalize the manual pull required. *Patent 2,942,599 assigned to Outboard Marine & Manufacturing Co., Waukegan, Ill. by Finn T. Irgens.*

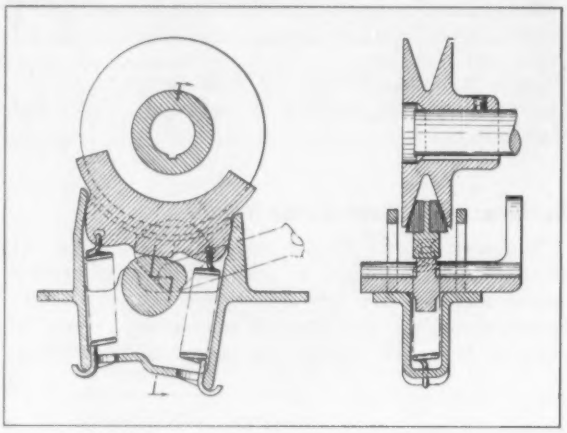
Pressure-Balanced Pump



Eccentrically meshing rotors in a gear-type pump operate under balanced pressure forces, particularly in the direction parallel to the axis. This balance is provided by several pressure-equalizing passageways. The gears mesh in such a manner that flow of liquid to and from the pockets is nowhere compressed by entrapment beyond the outlet pressure. *Patent 2,940,399 assigned to Symington-Wayne Corp., Salisbury, Md. by Clifford V. Zieg and Robert D. Lambert.*

Cone Brake Assembly

Small high-capacity brake assembly has a V-groove drum and external, floating, circular-segment shoes. Inward radial movement of the shoes to engage the drum is effected by either a cam mechanism or a hydraulic cylinder. Disengagement is effected by springs. *Patent 2,940,550 assigned to Rockwell-Standard Corp., by George P. Mathews.*



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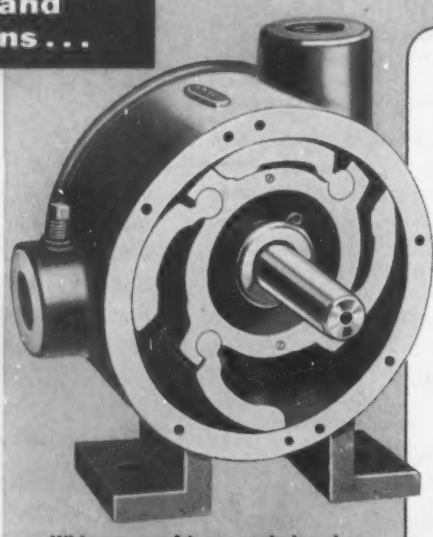

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• **Cast Iron Vanes and Cylinders** are precision-machined, then hone themselves to hard, glassy smoothness during operation—take up their own negligible wear—assure leakproof seal and fully-rated capacity for years and years.

• **Extra-large Air Space** provides 2 to 3 times more capacity per pump, permits use of smaller pump.

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Write for new catalog showing construction, types, sizes and specifications, plus Application Book containing many "how-to-do-it" blueprints.

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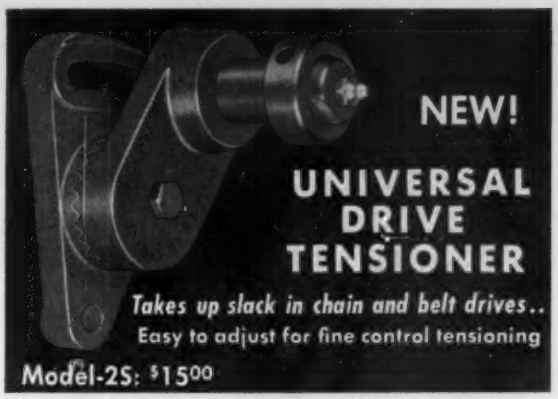

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Easy to adjust for fine control tensioning

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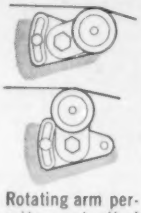

Rotating arm permits controlled tensioning at any point on a 360 degree arc, without changing base.

Reduce horsepower losses through belt slippage, eliminate shock loading on chain drives, increase the life of your equipment with the Universal Drive Tensioner. Two bolt mounting makes it more adaptable to machine frames. For single drives 2" long shaft furnished . . . also available are 3" and 4" long shafts for multiple width drives. This unit is also ideal as idler bracket in gear train. Contact your distributor or write . . .

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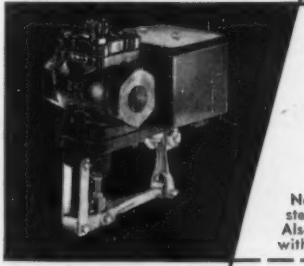
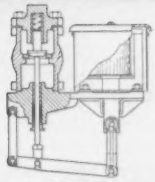
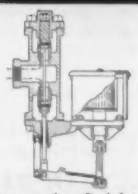
JOHNSON Direct Operated SOLENOID VALVES

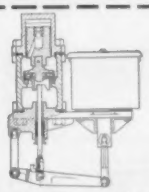




Normally closed service, stainless steel valve and seat. Sizes ⅜"-3". Also for normally open service, and with Jenkins Disc.



3-way valve. Stainless steel valves and seats. Sizes ½"-1½".



Dashpot construction, cushions closing to avoid water hammer. Jenkins Disc. Sizes ¾"-2".

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THE JOHNSON CORPORATION
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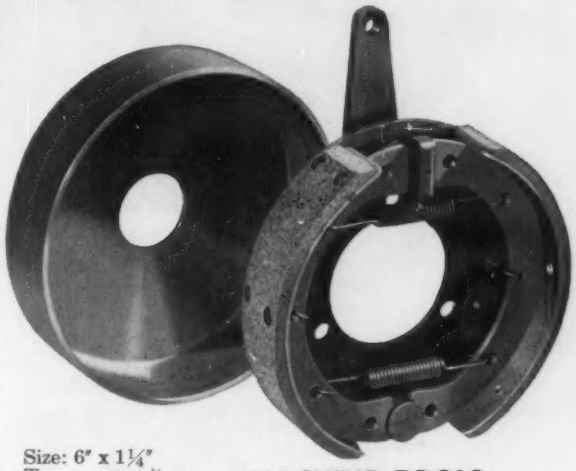
Circle 530 on Page 19

★★★★ NEW ★★★ FROM BENDIX

A VERSATILE MIDGET BRAKE FOR SUCH VARIED USES AS . . .



Size: 6" x 1¼"
Torque capacity: 3,250 in. lbs.

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Circle 532 on Page 19

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- Excessive Loads
- Controlled Acceleration
- Dynamic Braking
- Partial or Full Stall

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Circle 535 on Page 19

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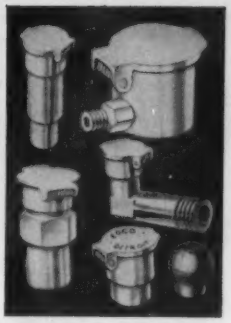

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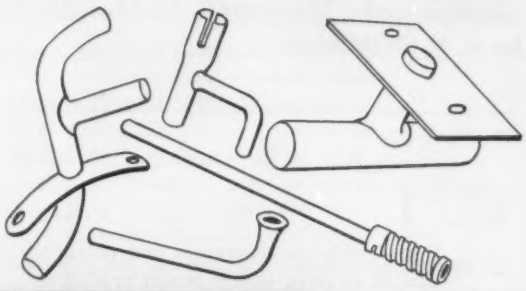

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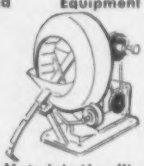

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Circle 541 on Page 19

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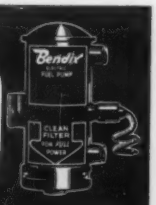

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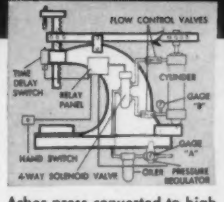

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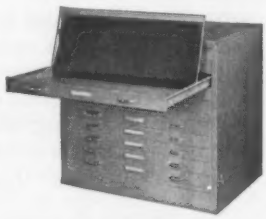

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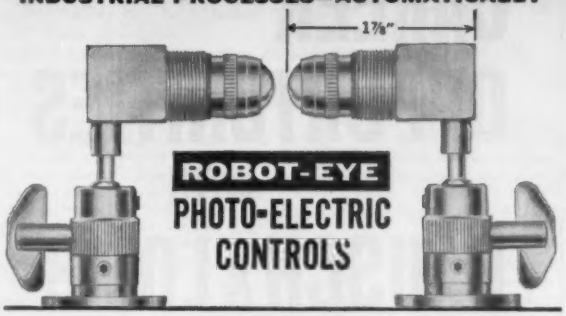

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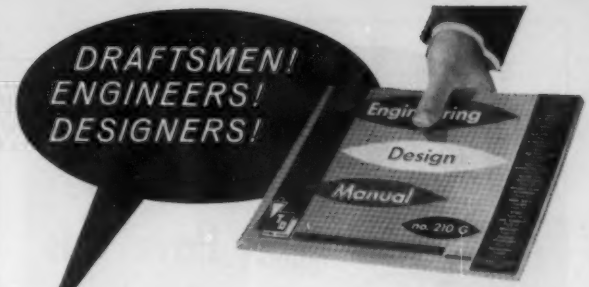

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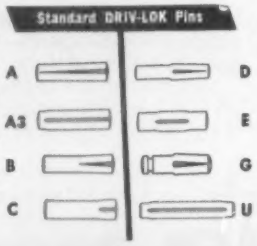

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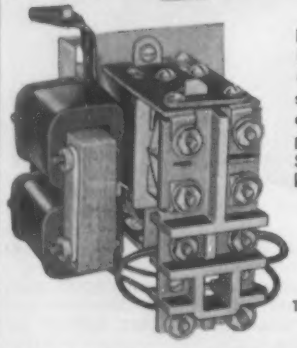

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Circle 554 on Page 19

Advertising Index

Abbott Ball Co., The 184
Accurate Bushing Co., Smith Bearing Division 43
Acme Chain Corporation 191
Allegheny Ludlum Steel Corporation 214
American Brake Shoe Co., Denison Engineering Division 76
American Chain & Cable Co., Inc., Automotive and Aircraft Division 165
American Engineering Co., Division of United Industrial Corporation 78
American Insulator Corporation 213
American Metal Climax, Inc., Climax Molybdenum Co. Division 52
American Smelting and Refining Co., Federated Metals Division 167
American Society for Metals 196
American Welding & Mfg. Co., The 50
AMP, Inc. 16
Automotive and Aircraft Division, American Chain & Cable Co., Inc. 165
Auto Ponents, Inc. 207

Babcock & Wilcox Co., The, Tubular Products Division 5
Baldwin-Lima-Hamilton, Standard Steel Works Division 57
Barksdale Valves 199
Bausch & Lomb 210
Beaver Precision Products, Inc. 186
Bellofram Corporation 178
Bellows Co., The, Division of International Basic Economy Corporation 100
Bendix Corporation, The 203
Bendix Corporation, The, Eclipse Machine Division 207
Benton Harbor Engineering Works, Inc. 183
Bethlehem Steel Co. 83
Bodine Electric Co. 1
Boston Gear Works .....Inside Back Cover
Brewer Machine & Gear Co. 203
Bunting Brass & Bronze Co., The 197
Bundy, Omaton Division 2

Cambridge Wire Cloth Co., The 90
Carr Fastener Co. Division of United-Carr Fastener Corporation 91
Chace, W. M., Co. 156
Chicago-Allis Mfg. Corporation 31
Chicago Lock Co. 198
Clare, C. P., & Co. 79
Climax Molybdenum Co., A Division of American Metal Climax, Inc. 52
Continental Felt Co. 209
Copperweld Steel Co., Aristoloy Steel Division 11
Copperweld Steel Co., Ohio Seamless Tube Division 187
Cotta Transmission Co. 209
Crawford Fitting Co. 33

Denison Engineering Division, American Brake Shoe Co. 76
Dillon, W. C., & Co., Inc. 205
Driv-Lok Sales Corporation 210
Duff-Norton Co., Coffing Hoist Division 166
Du Pont, E. I., de Nemours & Co., Inc. 67, 68, 93
Durametallic Corporation 160

Eclipse Machine Division, The Bendix Corporation 207
Elastic Stop Nut Corporation of America .. 208
Electro Devices, Inc., Servospeed Division .. 184
Emerson Electric 69
Exalco Manufacturing Co. 158
Eynon-Dakin Co. 205

Fairbanks, Morse & Co., Magneto and Engine Accessories Division 173
Fairchild Engine & Airplane Corporation, Stratos Division 168
Fairfield Mfg. Co., Inc. 195

Federated Metals Division, American Smelting and Refining Co. 167
Fenwal, Inc. 94
Formed Steel Tube Institute, Inc. 29

Garlock, Inc. 44
Gates Rubber Co., The 54
Gear Specialties, Inc. 72, 73
General American Transportation Corporation, Parker-Kalon Division 96
General Gas Light Co., Humphrey Products Division 200
General Industries Co., The 179
Gleason Reel Corporation, Tormag Division .. 204
Goodrich Chemical, B. F., Co., A Division of The B. F. Goodrich Co. 70

Halex Corporation 180
Handy & Harman 38
Hassall, John, Inc. 160
Humphrey Products Division, General Gas Light Co. 200
Hunt Valve Co. 102
Hydro-Line Manufacturing Co. 62

Industrial Tectonics, Inc. 39
International Basic Economy Corporation, Bellows-Valvair Divisions 100
International Harvester Co. 89
International Nickel Co., Inc., The 63

Jeffrey Manufacturing Co., The 75
Johns-Manville 41
Johnson Corporation, The 203

Kaydon Engineering Corporation, The 21
Kennametal, Inc. 42
Keuffel & Esser Co. 45
Keystone Steel & Wire Co. 37

Leiman Bros., Inc. 202
Lewellen Manufacturing Co. 15
Lexington Controls Inc. 206
Link-Belt Co. 9
Logansport Machine Co., Inc. 51

McQuay-Norris Manufacturing Co., Electric Products Division 175

MacLean-Fogg Lock Nut Co. 163
Madison-Kipp Corporation 58
Mayline Co., Inc. 208
Mead Specialties Co. 71
Micro Switch Division, Minneapolis Honeywell Regulator Co. 46, 47
Midvale-Heppenstall Co. 7
Minneapolis Honeywell Regulator, Micro Switch Division Co. 46, 47
Minnesota Rubber 204
Modernair Corporation 40
Monsanto Chemical Co., Plastics Division ..64, 65

National Acme Co., The 53
Nichols, W. H., Co. 168
Norgren, C. A., Co. 82

Ohio Seamless Tube Division of Copperweld Steel Co. 187

Palnut Co., The, Division of United-Carr Fastener Corporation 192

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BPA NBP

backtalk——

—A Wise Move

Moving into a more desirable neighborhood on the editorial masthead, Clare Wise is now an associate editor. A member of that part of our staff which produces the Engineering News section, he joined MACHINE DESIGN as an assistant editor in 1957.

Clare was born in Michigan and educated at Hillsdale College and the University of Michigan. He received a B.S. degree, then

studied electronics for two more years while serving in the Air Corps during World War II.

Interested in writing while majoring in science, Clare wrote for his college newspaper. He handles many of our News feature articles and for several years has been responsible for the new-car roundup series. His wearing of the "automotive editor" hat even brought him the assignment of preparing this issue's article on go-carts, which starts on Page 24. Incidentally, a nice picture of Clare's left hand appears in this article, holding the cylinder head of an engine. Apparently the kart kraze has kept the people at Tecumseh so busy building engines that they didn't have time to take some pictures we requested, so they shipped an engine to us so we could have pictures made.

After a hard day in the News department, Clare likes to relax by building things in his basement. In fact, he built the basement—and the house attached to it. When there is time, he also likes to hunt, fish, and play golf.

—Wonderful Year 1935

Looking through the Engineering News pages of this issue and thinking about the rapid strides of Progress, we took to speculating on what made the news when MACHINE DESIGN was a young reporter. Hauling out an early bound volume and flipping through its pages, we noted the following items printed 25 years ago:

Those designers who put a crimp in the ice delivery business as a future profession now have their guns out for the garbage man. Don't be surprised to see an announcement soon of an electric garbage incinerator which perhaps will dispose of bottles, cans and whatnots in addition to garbage and leave you a small residue that you can spread on the geraniums.

1960 incinerators still can't take care of bottles and cans; however, they are good at geraniums and whatnots.

The "big push" in the air conditioning industry is on. . . . This type of equipment is expected to move into the volume field this year.

How did people live in the dark days before air conditioning?

From the August issue:

Indications are that by September over eighty per cent of this year's graduating class of Cornell University will have found employment. By the middle of last June fifty per cent of the graduates already had been placed, the most encouraging record in four years.

Obviously, the recruiters weren't on their toes.

Our favorite news item of 1935 came under the staid headline, "More Friendly Spirit Is Becoming Evident Toward High-Speed Machines." It begins:

Still another cotton-picking machine finds its way to the front . . . .

—Conferences and Confidences

Delmar W. Karger, who has written a number of articles for MACHINE DESIGN on the subject of new-product development, will direct an unusual government-sponsored seminar on this subject. Professor Karger is head of the department of management engineering at Rensselaer Polytechnic Institute. This fall, under his direction, 50 owners and presidents of small businesses will participate in a research, education, and consultation program dealing with problems which small manufacturers encounter in developing and exploiting new products. A grant for the project was obtained from the Small Business Administration.

In order to judge the program's effectiveness, attendees will present—in sealed envelopes—their companies' new-product plans. A year after the conference, these envelopes will be opened and comparisons will be made.

Advertising Index

Parker-Kalon, Division of General American Transportation Corporation 96
Penn Engineering & Manufacturing Corporation 80, 81
Purolator Products, Inc. 88

Recordak Corporation 87
Reliance Electric and Engineering Co. 66
Rivett, Inc. 159
Robbins & Myers, Inc. 98
Rollway Bearing Co. 56

Servospeed, Division of Electro Devices, Inc. ... 184
Shell Oil Co. 92
Shenango Furnace Co., The, Centrifugally Cast Products Division 194
Sigma Instruments, Inc. 189
Simmons Fastener Corporation 55
SKF Industries, Inc. 177
Skinner Chuck Co., The, Skinner Electric Valve Division 85, 86
Smith Bearing Division, Accurate Bushing Co. 43
Snap-Tite 155
Southwest Products Co. 207
Speco, Inc. 204
Speed Selector Inc. 206
Spencer Turbine Co., The 161
Sperry-Rand Corporation, Vickers, Inc., Aero-Hydraulics Division 35
Square D Co. 101
Stackpole Carbon Co. 157
Standard Instrument Corporation 209
Standard Pressed Steel Co., Industrial Fastener Division 84
Standard Steel Works Division, Baldwin-Lima-Hamilton 57
Stephens-Adamson Mfg. Co., Standard Products Division 204
Stratos, A Division of Fairchild Engine & Airplane Corporation 168
Superior Carbon Products, Inc. 201
Superior Tube Co. 74

TA Mfg. Corporation 209
Teletype Corporation 99
Thomas Flexible Coupling Co. 170
Thomson Industries, Inc. 77, 193
Timken Roller Bearing Co., The, Steel and Tube Division ..... Back Cover
Tomkins-Johnson Co., The 97
Torrington Co., The 13
Torrington Co., The, Specialties Division 188
Trent Tube Co. 95
Twin Disc Clutch Co. 169

Union Carbide Corporation, Silicones Division 49
United-Carr Fastener Corporation, Carr Fastener Co. Division 91
United-Carr Fastener Corporation, The Palnut Co. Division 192
United Industrial Corporation, American Engineering Co. Division 78
U. S. Electrical Motors, Inc. ... Inside Front Cover
Universal Electric Co. 171

Valvair Corporation, Division of International Basic Economy Corporation 100
Veeder-Root 181
Versa Products Co., Inc. 205
Vickers, Inc., Division of Sperry-Rand Corporation, Aero-Hydraulics Division 35
Vulcan Electric Co. 170

Warner Electric Brake & Clutch Co. 59, 60, 61
Warrick, Charles F., Co. 210
Waterman Hydraulics Corporation 27
Webster Electric, Oil Hydraulics Division 48
Wisconsin Motor Corporation 176
Wittek Manufacturing Co. 182

Engineers Available or Wanted 210

Circle 555 on Page 19→

profiles in plastics

by **B. FRANK HANTZ,** *Vice President*
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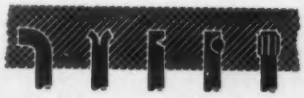

INSERTS . . . may be used in plastic parts as fasteners, to support loads, simplify handling or facilitate assembly. (They may serve functional purposes or may be used purely for decoration.) Smooth rod inserts (see sample above) may be securely anchored by bending, splitting, notching, swaging or knurling. Other types of inserts are fully covered in Aico's booklet "Good Plastics Design Makes Cents." Coupon will bring your FREE copy.

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A-L ANSWERS YOUR QUESTIONS

ON VACUUM MELTED STEELS AND ALLOYS

Q. Where are vacuum melted alloys best suited?

A. For exacting applications—including materials for rockets, missiles, and jet engines. And other places where expensive machined parts are involved. In highly stressed parts where failure is highly costly. Where increased reliability is vital.

Q. What are the advantages of A-L vacuum melted alloys?

A. You get parts with optimum quality for critical applications—higher mechanical properties, better fatigue strength, improved toughness, and better transverse ductility. You also get maximum insurance against internal defects through improved cleanliness and decreased gas content. And hot and cold workability are improved, the material is more homogeneous, and properties are better.

Q. How are these metals made?

A. A-L uses all three of the vacuum melting processes. Consumable electrode vacuum arc remelting is used to produce A-L Consutrode® steels and alloys in ingots up to 20,000 pounds in weight. Induction vacuum melting is used to produce 2,000 pound heats of Allegheny Ludlum Invac materials. And remelting Invac electrode stock by the consumable electrode process produces A-L Invacutrode steels and alloys that have the best possible combination of chemistry control, cleanliness, and homogeneity.

Q. Specifically, what metals are available in A-L's premium quality melting?

A. Most of the steels and special alloys—low alloy steels, bearing steels, stainless steels, tool and die steels, and high temperature steels and alloys.

Q. In what forms are these A-L special steels available?

A. In all commercial mill forms—plates, sheet, strip, billet, bar, wire, tubes, and even extrusions.

Q. How do these vacuum melted alloys compare in cost with ordinary alloys?

A. Naturally vacuum melting costs more. Consutrode alloys are the least expensive, followed by Invac alloys and Invacutrode alloys. Their use is economically justified by the improvement of quality in the finished part, the quality required by the severity of the manufacturing process involved, and the increase in the yield of sound parts.

Q. Where can I get more information?

A. Ask your A-L representative for your copy of "Modern Melting at Allegheny Ludlum." It gives technical data on the new melting techniques and quality improvements in materials. Or write: ***Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pennsylvania. Address Dept. MD-8.***

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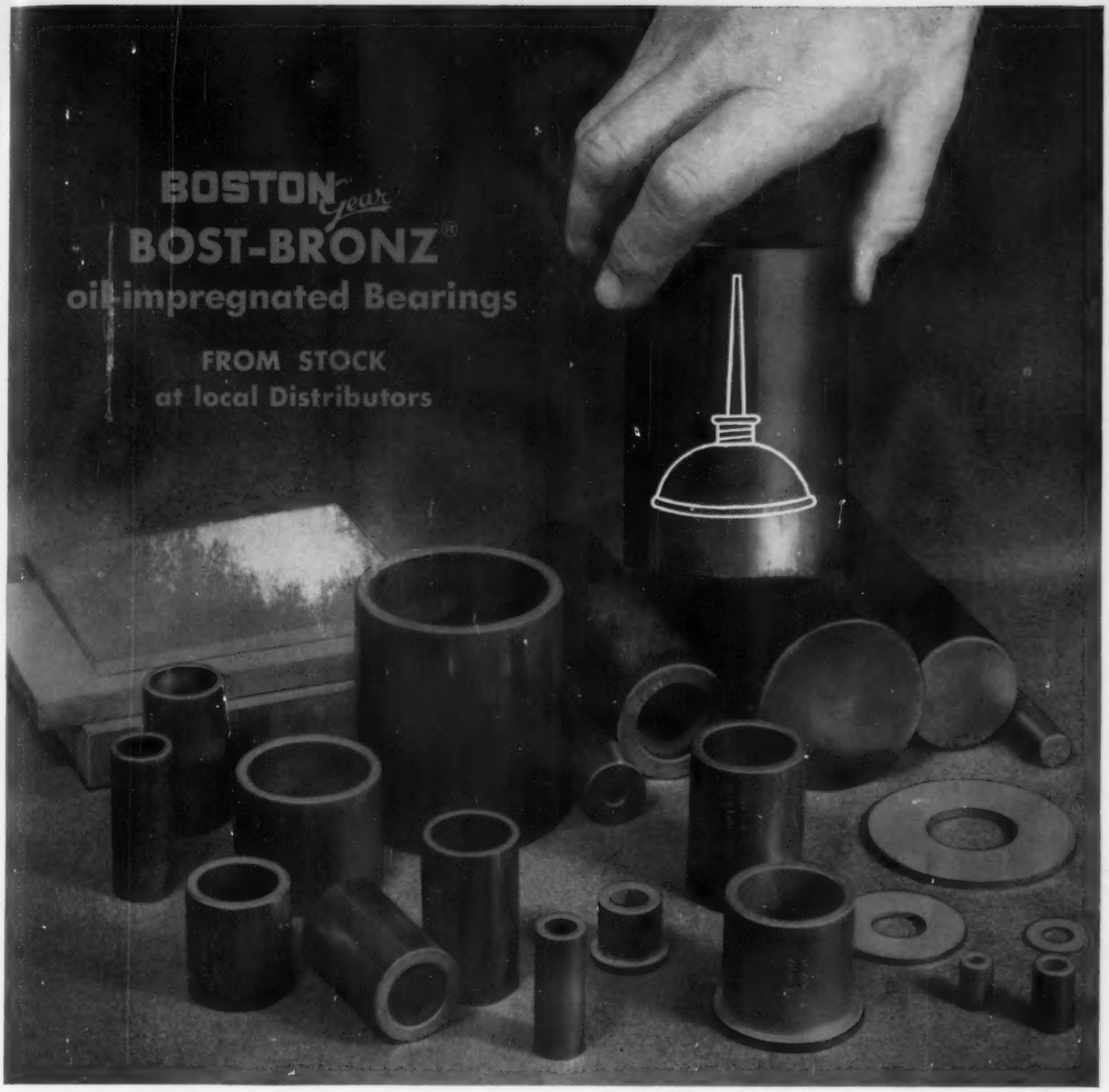

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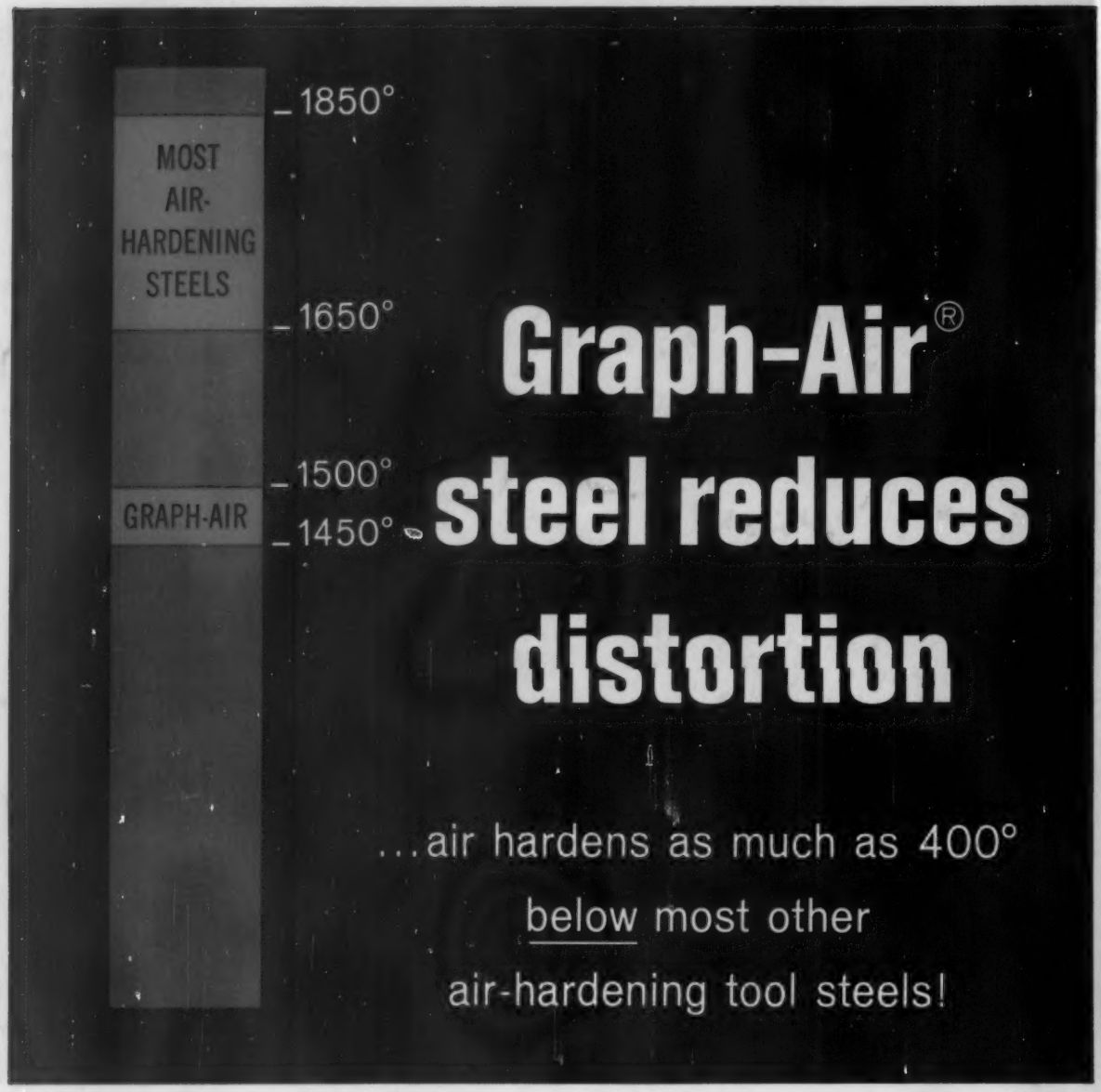
Circle 402 on Page 19



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Circle 403 on Page 19